IRON AND STEEL ENGINEER

J. F. KELLY, Editor

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AI&SEE
INSPECTION TRIP
COMBUSTION ENGINEERING DIVISION
and
OPEN HEARTH SUPERINTENDENTS
DONNER STEEL COMPANY BUFFALO, N. Y.
MARCH 31, 1927.

EDITORIALS

ANNUAL CONVENTION AND IRON AND STEEL EXPOSITION

The Annual Convention and Iron and Steel Exposition of the Association of Iron and Steel Electrical Engineers, being held in Pittsburgh, at the Syria Mosque, June 13th to 18th, will, in all probability, be the Association's crowning effort in Conventions and Expositions.

The technical program will embrace the subjects of:

Electrical heating.

Safe practices in connection with the operation of high tension power.

Ball, roller and sleeve type bearings for heavy rolling mill applications.

The applications of synchronous motors to large rolling mill drives.

A large boiler plant installation in the steel industry.

Flat suspended roofs in open hearth furnaces.

A recent electrical installation in one of the large steel plants (one of the largest in the United States.)

Steel plant illumination.

The Iron and Steel Exposition will be, by far, the largest that has ever been held under the auspices of the Association. Every available foot of space in Syria Mosque will be occupied by the manufacturers of electrical, mechanical, combustion and safety apparatus. Every development in these arts for the past year will be exploited and brought to the attention of the presidents, executives, engineers, master mechanics, and maintenance superintendents of the iron and steel industry. During the past year there has been an unusual number of radical departures in operating practices in the iron and steel industry, and these will be brought to the attention of the visitors and guests who attend the Iron and Steel Exposition. The exposition will be open practically each afternoon and evening and a new feature has been added. The exposition will, for the first time, be open all day Saturday and Saturday evening. This day has been set aside for the employees of the maintenance departments of all the industries in Pittsburgh and surrounding territory. This new feature will give the operating employee an opportunity to acquant himself with the developments that he will have something to do with in his future operations.

The June issue of the Iron and Steel Engineer will be devoted exclusively to the Twenty-third Annual Convention and Iron and Steel Exposition of the Association of Iron and Steel Electrical Engineers.

This number will contain all of the advance papers to be read at the technical sessions, complete program of convention and exposition, lists of exhibitors, floor plans, points of interest, items of interest and all other information which will be of use to those 15,000 to 20,000 men who will be in attendance during the week of June 13th to 18th.

An additional feature of this number will be a completely illustrated article describing one of the most modern electrified mills which has just been recently completed in the Pittsburgh district.

The official Hotel Headquarters will be: -First, Webster Hall (which is a bachelor hotel), second, the Schenley Hotel, which we would recommend for those who will be accompanied by their wives, third, William Penn Hotel (the largest hotel in Pittsburgh), fourth, Fort Pitt Hotel, University Club, Pittsburgh Athletic Association and Morrowfield Apartments.

The official headquarters where all of the technical sessions will take place and most of the social functions will be the Pittsburgh Athletic Association's Annex (which is the old University Club), located about 75 feet from the Syria Mosque.

For any information relative to the Convention and Exposition, address Association of Iron and Steel Electrical Engineers, 705-6 Empire Building, Pittsburgh, Pa.

INSPECTION TRIP

The Combustion Engineering Division of the Association of Iron and Steel Electrical Engineers, together with a large number of Open Hearth Superintendents of the steel plants in the United States, were the guests of the Donner Steel Company, Buffalo, N. Y., on Thursday, March 31.

The Donner Steel Company opened the plant for the inspection of the visitors and one particular feature attracted the attention of those who were interested in open hearth practices. The Donner Steel Company has installed two flat suspended roofs. One of these roofs is in connection with a 100 ton basic open hearth furnace, fired with coke oven gas and tar. At the time of the visit this roof had been on close to 400 heats.

On another furnace the installation of a flat suspended roof had just been completed and it was possible to make a thorough inspection of the construction of the roof, as well as the general lines of the furnace.

At noon all of the visitors and guests were ushered to the main dining room of the Donner Steel Company, where an elaborate luncheon was served. After the luncheon a round table discussion was conducted by Mr. W. J. Harper, who is the Fuel Engineer of the Donner Steel Company, and who also is the Chairman of the Combustion Engineering Division of the A. I. & S. E. E.

Mr. J. W. Donner, General Manager of the Donner Steel Company described the developments which lead to the adoption of the flat suspended roof. It was Mr. Donner's opinion that the adoption of the flat suspended roof lengthened the life of the front and rear walls.

About 35 of the largest steel plants in the United States were represented at this meeting. The Combustion Engineering Division is to be congratulated upon one of the most successful Committee meetings held in the history of the A. I. & S. E. E.

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Electrification of Sheet Mills

By J. S. MURRAY*

Mr. J. S. Murray, Electrical Engineer, Follansbee Bros., Toronto, Ohio, has contributed to the Iron and Steel Industry, a very comprehensive and complete article, describing one of the most modern and completely electrified Sheet and Tin Plate Plants in the United States. One of the interesting and novel features that the author brings to the attention of the reader is the Follansbee Forge, which reduces the ingots into billets, from which are made the only hammer process, Open Hearth Steel Sheets and Tin Plate in America. It is claimed that the hammer process eliminates the blow holes or air cells, and gives to the steel, a compactness, a strength and ductility, unknown to rolled steel.

The Iron and Steel Engineer feels that it has rendered a real service to the Iron and Steel Industry, in presenting Mr. Murray's article to its readers. Editor.

THE Toronto Works of Follansbee Brothers Company is located at Toronto, Ohio, on the banks of the Ohio River, about seven miles north of Steubenville, in close proximity to valuable natural resources such as coal, natural gas, water, etc., in addition to excellent transportation facilities by River and Cleveland and Pittsburgh and P.C.C. & ST.L. Divisions of the Pennsylvania Railroad.

Construction commenced on the plant in November, 1919, and operations started in January, 1921. Fig. 1 shows a general plan to scale of the plant, which consists of the following buildings: Power Plant, Open Hearth and Gas Producers, Stock House, Hydraulic Press and Bar Mill, Substation, Sheet Mills, Annealing Department, Warehouse, Shops, Powdered Coal Plant, Chemical Laboratory, Physical Laboratory, Paymaster's Office and Gas Washing Plant. Fig. 2 shows a view of the Mill.

PRODUCT MANUFACTURED

This plant is engaged in the manufacture of "Follansbee Forge" full finished sheets, in gauges ranging from 10 to 24, and in sizes up to a maximum of 48" wide and 144" long.

The production of the plant for the most part is furnished the automobile trade for fabricating such sheet metal parts as bodies, doors, window panels, hoods, fenders, aprons, radiator casings, winterfronts, etc. Considerable tonnage is also furnished the metal furniture trade, for the manufacture of such products as fireproof safes and cabinets, metal desks, metal beds, refrigerators, etc. Its product is also furnished to the radio industry for the manufacture of horns, cabinets, etc., as well as to the telephone industry for subset housings. The toy industry is also a consumer of sheets from this plant, which are used for manufacturing light weight metal toys. The plant specializes in the manufacture of sheets for difficult stamping and drawing operations, also nickel plating stock, stretcher leveled stock, milk can stock, register stock, and many special sheets to meet individual consumers requirements.

The capacity of the plant is 75,000 tons per annum.

POWER PLANT

The Power Plant is a brick building of fireproof construction. All electric power used is generated in this Power Plant, as well as sufficient steam for forging operations in the mill and various other requirements. Steam is furnished by 6 class OT No. 23 water tube Badenhausen boilers, 591 BHP each, 200 lb. pressure equipped with super-heaters, Tracey purifiers and Westinghouse stokers, Sturtevant size 4 draft fans direct connected to 77 H.P Terry steam turbines are used for forced draft. The stokers are operated by American Blower engines. Coal is trucked from the Company's coal mine to the Power House, crushed and elevated to bins located over the stokers, after which it falls by gravity into the stokers. Ash handling equipment is located in the basement and is elevated from there by means of a skip hoist for distribution in the usual manner. Skip hoist is driven by General Electric 15 H.P. KTE-B 3 phase, 60 cycle, 220 volts motor, high resistance rotor type with CR-9510 AC brake and CR-7498-J-1 control and push button station.

Coal crusher is driven by Westinghouse 25 H.P. 220 V. 3 phase, 60 cycle induction motor, 1160 RPM with type AF starter and push button station. Elevator and conveyors are each driven by General Electric 7½ H.P. wound rotor induction motors, 900 RPM, with drum controllers and class 11100 Westinghouse starters.

There are three Cameron 3 stage pumps direct connected to 75 H.P. non-condensing Kerr turbines and Webster-Lee feed water heater for furnishing boiler feed water. Fig. 6-B shows view of stokers and boiler room.

Turbine Room.

Fig. 2 and 3 shows a general view of the Turbine Room and switch board. The equipment consists of two 3,000 K.W. 2,300 V. 3 phase, 60 cycle, 80 per cent power factor turbo generator units with surface condensers and one 1,500 K.W. 2,300 V. 3 phase, 60 cycle, 80 per cent power factor turbo generator unit with surface condenser, all of Westinghouse manufacture.

Excitation.

Excitation is furnished for all three turbo generators by 50 K.W. 125 V. Westinghouse motor generator set with an emergency unit having a duplicate generator but direct connected to Westinghouse steam turbine.

Main Switchboard.

The main switchboard is of General Electric manufacture and consists of 17 panels as follows:

*Elec. Supt., Follansbee Brothers Co., Toronto Plant, Toronto, Ohio.

Panel No. 1, swinging bracket with the following equipment:

1 Synchronizing indicator.
2 Voltmeters, type M-2 175 V. with 135 V. scale.

Panels No. 2 and 3, D.C. exciter panels with the following equipment mounted on each panel:

1 Ammeter type DH-3, 100 amp. scale.
1 Voltmeter DH-3, 150 V. scale.
1 Field rheostat mounting.
1 Potential receptacle, 4 point with plug.
1 Lever with type D, 250 V. 600 amp.

Panel No. 4, voltage regulator panel upon which is mounted:

1 Voltage regulator, type TA-125 form K complete with resistance and condensers.
1 Potential transformer, 2,300-100 V. 200 Watt, 60 cycle with fuse.
1 Double throw lever switch for transferring regulator to either exciter.
1 Field switch, double pole, single throw, 200 amp. with discharge resistance for generator fields.
1 Potential receptacle, 5 point.
1 Synchronizing receptacle, 6 point.
1 Set of current and potential calibrating receptacles on front of panels with plugs.

The following are mounted remote from these panels:

1 Oil circuit breaker, type K-32-A, non-automatic triple pole, single throw, 7,500 V. 1,200 amp. mounted on pipe frame work.
3 Disconnecting switches, type LG, single pole, single throw, 2,500 V. 1,200 amp, on marble bases with barriers.

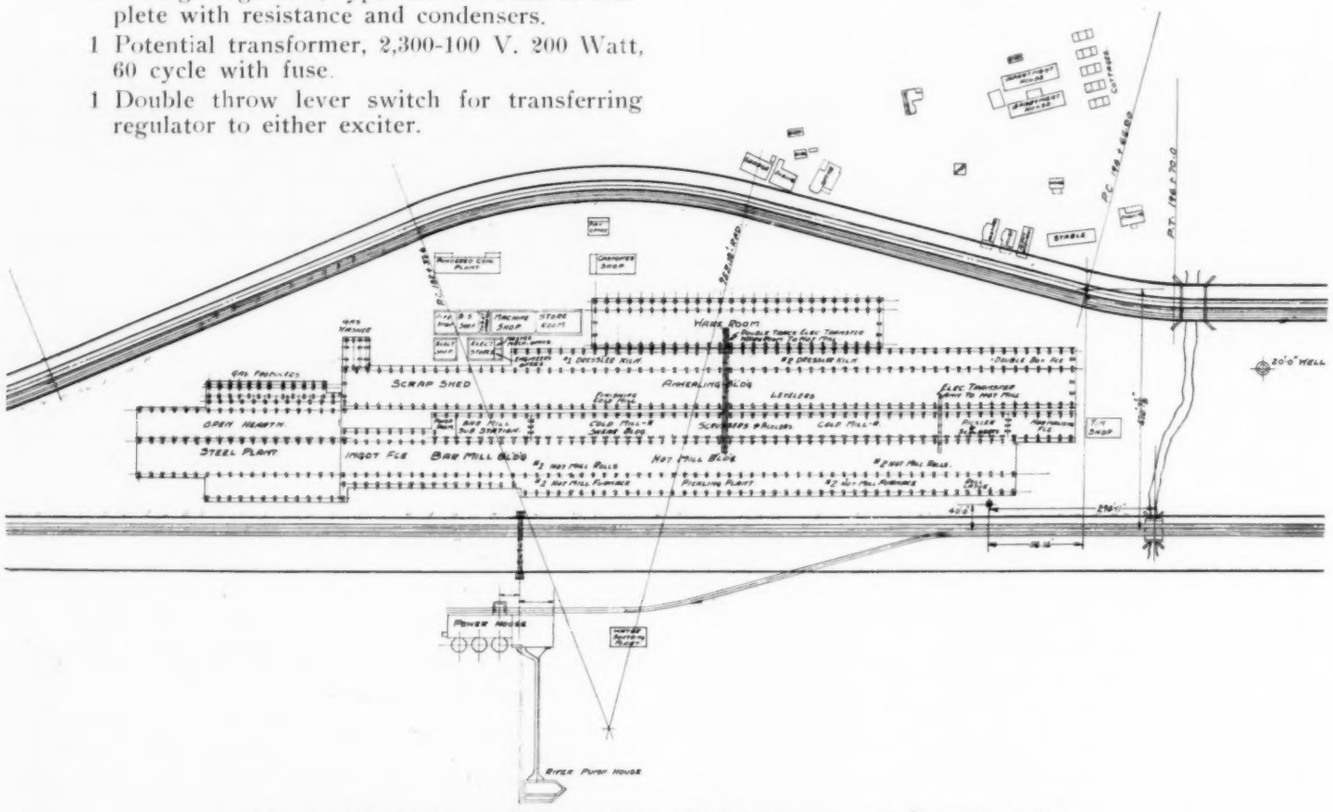


FIG. 1—General Layout, Toronto Plant, Follansbee Bros. Co., Toronto, Ohio.

Panel No. 5, A.C. metering panel upon which is mounted:

1 Frequency indicator.
1 Graphic power factor indicator.
1 Curve drawing ammeter, type C-4.
1 Curve drawing wattmeter C-9.
1 Totalizing wattmeter.
1 Westinghouse temperature indicator type D.T.

Panels No. 6 and 7, two 3,000 K.W. A.C. generator panels, 3 phase, 60 cycle, 3 wire, each consisting of the following:

3 Ammeters, type H-2, 5 amp. with 600 amp. scale.
1 Field ammeter, type DH-3.
1 Indicating wattmeter, type H-2.
1 Watthour meter, type DS-6.
1 Control switch for electrically operated governors on turbines.

Necessary potential transformers and current transformers.

Panel No. 8, this panel is a duplicate of Panels No. 6 and 7, except as to size for 1,500 K W. generator with the following exception: The oil circuit breaker is type K-32-A, non-automatic, triple pole, single throw, 15,000 V. 600 amp.

Panel No. 9, blank panel for future generator.

Panels Nos. 10, 11, 12, 13, 14, 15 and 17 are feeder panels, 3 phase, 3 wire, 1,000 amp. capacity upon which is mounted the following equipment:

1 Ammeter, type H-2, 5 amp. with 1,500 amp. scale.
1 Indicating wattmeter, type H-2.
1 Watthour meter, type DS-6.
1 Set combined ammeter transfer and current test receptacles with plug.

Mounted apart from those panels are the following:

1 Oil circuit breaker, type K-32-A, triple pole, single throw, full automatic, 7,500 V. 1,200 amp. mounted on pipe frame work with manual operating mechanism.

2 Relays time limit overload, single pole plunger type.

3 Disconnecting switches, type IG, single pole, front connected, 2,500 V. 1,200 amp. on marble bases.

Necessary potential and current transformers. Panel No. 16, this is a duplicate of the other feeder panels, excepting the oil circuit breaker, which is a duplicate of the one used on No. 3 Turbo Generator, with the exception that it is automatic instead of non-automatic. All feeder panels are provided with bell alarm. The above feeders furnish power to the following units:

Panel No. 10 controls powers to Reversing Bar Mill Drive.

Panel No. 11 furnishes power for motor genera for sets and step down transformers and Air Compressors.

Panel No. 12 controls power circuit to 1,500 H.P. Sheet Mill motor No. 1.

Panel No. 13 controls power to Sheet Mill motor No. 2.

Panel No. 14 controls power circuit to mine substation, well pumps and yard and residence lighting distribution.

Panel No. 15 controls power to River Pump House.

Panel No. 16 furnishes power to all lights in the Mill and Yards, as well as station transformers for the Power Plant.

Panel No. 17 controls power to Cold Roll Drive.

Station Transformers. 230 V. 3 phase power is furnished for coal, ash, pump and other motors in the Power Plant and water-treating plant from three 50 K.V.A. 2300-230 V. Packard transformers located in a Mezzanine floor directly under the switchboard. A 10 K.V.A. single phase, 2300-230 V. transformer is located here also for Power Plant lights. An emergency feeder is also provided from the mill substation to take care of those important drives such as boiler feed pumps in case of transformer failures at this point, as may be seen from single line diagram Fig. 5. The field rheostats for the Turbo Generators are also located on this Mezzanine floor with operating chains etxending from switchboard panels above. Fig. 6 shows section through turbine room.

The main cables from the generators to the oil switches are run open on the cellar ceiling and supported on General Devices & Fittings Company insulators, while the outgoing feeders are run in steel conduit from the feeder oil switches to the lightning arrester towers. All other wiring in the turbine room is run in steel conduit embedded in concrete floor. All wiring in the boiler house is run in steel conduit.

Air ducts of size recommended by the manufacturer are provided for the turbo generators so that sufficient clean air is taken from the outside of the building, passed through generators and deposited in the turbine room cellar. However, blowers or air washers are not provided as winding temperatures at full load are within permissable values as shown by the embedded thermocouples in the stator windings of the generators. A 10 ton hand operated Whiting crane is installed in the Turbine Room. The output in K.W.H. is 2,500,000 per month. Fig. 6-A shows power factor chart and Fig. 13 shows view of wattmeter chart.

FIG. 2—Bird's Eye View, Toronto Plant.

Lightning Protective Apparatus. Each of the outgoing feeders are provided with graded shunt multigap lightning arrestors, single pole, for indoor use on 2300 V. circuit with choke coils 1000 amp. double coil for indoor use. As an additional precaution, an oxide film arrester is connected to feeder to the coal mine. Lightning protective apparatus is mounted in a compartment directly above the main

FIG. 3—Main Power Plant, showing 2—3000 kw. and 1—1500 kw. Turbine.

switchboard, and is of General Electric manufacture. Fig. 7 shows view of Power Plant.

Pump House.

A Pump House of concrete construction is located in the Ohio River and contains the following pumping units:

2 5000 GPM Allis Chalmers pump units consisting of 75 H.P. 2300 V. Allis Chalmers induction motors with Westinghouse automatic controls

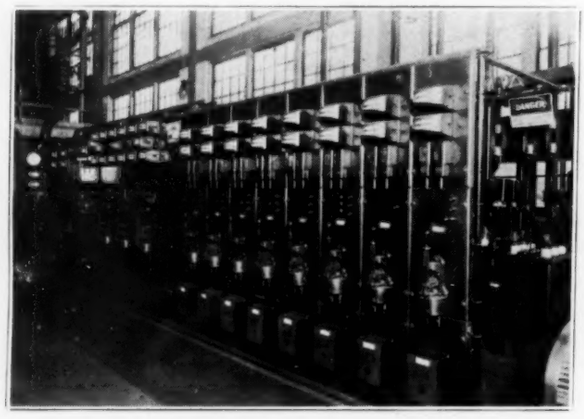


FIG. 4—2300 Volt. A. C. Switchboard, Main Power Plant.

for furnishing condensing water to the condensers on 3000 KW turbo generator units.

1 Similar unit, except 60 H.P. motor and 2500 GPM with duplicate Westinghouse control for furnishing condensing water to condenser on 1500 kilowatt unit. Control is Westinghouse type F.

2 5000 GPM Allis Chalmers units direct connected to 125 H.P. Allis Chalmers induction motors 2300 V. and hand starters for furnishing water to Scaife water treating plant and certain Open Hearth operations. Fig. 8 shows a view of this Pump House and the transmission line to it.

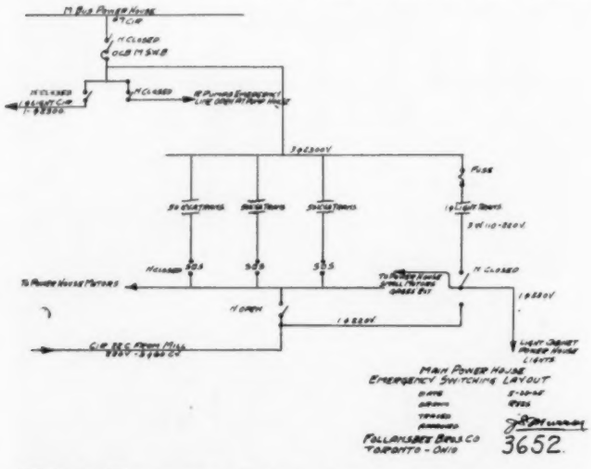


FIG. 5—Emergency Switch layout for boiler feed pumps and station lights.

There are some other small motors used for sump pumps and priming pumps in this Pump House at 230 Volts A.C. All 2300 V. wiring in this Pump House is lead cable, 3 conductor, 6600 V. with G & W pot heads. While all other wiring is R.C. in steel conduit with Crouse Hinds condulets.

Scaife Treating Plant: Fig. 9 shows a view of Scaife Water Treating Plant for treating boiler feed water, each tank having a capacity of 80,000 gal. The electrical equipment consists of 2 Frederick Centrifugal Pumps direct connected to 20 H.P. 230 V. Westinghouse induction motors, also two 5 H.P. Westinghouse motors operating agitators. The lights

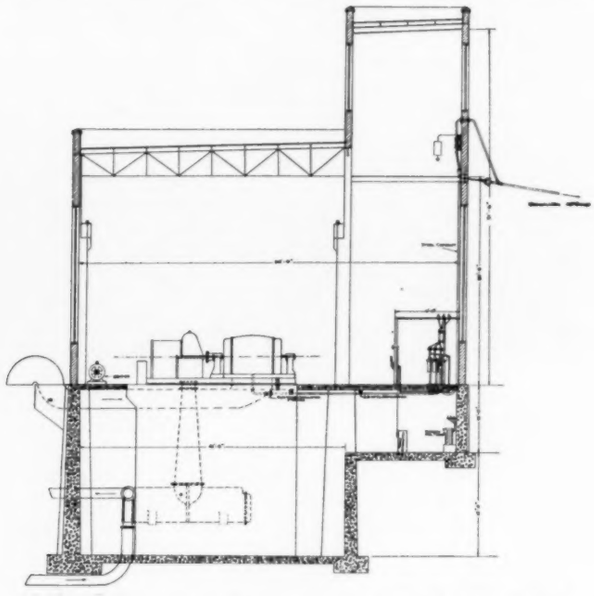


FIG. 6—End elevation of Main Turbine Station, showing location of air ducts, main generator cables to switchboard, switchboard, and station tranformers.

in this building as well as the Pump House are furnished by the Power Plant transformer equipment.

2300 V. Distribution. Power is distributed to the various departments at 2300 V. 3 phase, 60 cycle, between the Power Plant and Mill as shown on Fig. 10 by means of steel bridge, which also carries main steam line to the Mill buildings. Type B Ohio brass disc insulators are used on all dead ends with Garten Daniels choke coils and lightning arresters, except as noted in the Power Plant. All of the feeders mentioned in the Power Plant, except the Mine substation, pump house and light feeders are 500,000

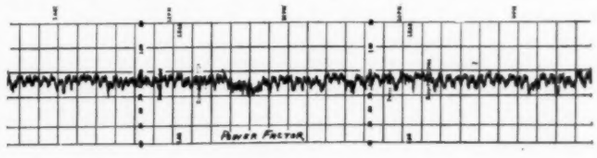


FIG. 6A—Chart showing Power Factor, Main Generator Station.

C.M. 10,000 V. VC covered stranded weather proof copper conductors while the Mine substation and light circuit is No. 2 B&S gauge, same insulation. Feeder to Pump House is No. 1 B&S gauge W.P. solid wire. Feeders from Panels Nos. 10, 11, 16 and 17 go into the Mill substation, while feeders from Panels Nos. 12, 13, 14 and 15 go direct to the con-

trol rooms at those drives. All 2300 V. feeders entering the buildings are dead ended on the inside of the building on the roof trusses, and are carried inside of the buildings from the top cord of the roof trusses on suitable insulators bolted to them, and are out of easy reach from possible intereference. The feeders are carried down into the control houses or substation in steel conduit, or fiber conduit, provided in each case with weather proof fittings. All 2300 V. cables and conduits are painted bright red.

FIG. 6B—Boiler Plant showing Stoker layout.

Fig. 12 shows single line diagram of the high and low tension system. Proper fiber signs are installed permanently on all feeders where feed back possibilities exist due to the desire to install double bus system and duplicate feeders because of the importance of continuity of service.

Low Tension Wiring. All low tension wiring in the Plant is double braid, rubber covered, run in steel conduit with Crouse-Hinds condulets and fiber conduit with suitable sittings in each case. The majority of the circuits in the mill are run open on the roof trusses and supported by Efficiency Cable Supports with weather-proof wire. All control wiring is either No. 10 or 12 B&S gauge stranded conductor. Square D safety switches are in use

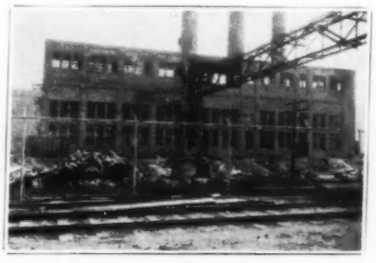


FIG. 7—External view of Main Power Plant.

throughout the plant, except a small number of V.V. switches, which are installed outdoors on lighting circuits. All mill and yard lights are operated on 220 volts and power is furnished from 200 KVA Packard transformer located in mill substation. All lighting units are 14" and 18" R.L.M. dome, steel enameled Benjamin reflectors taking lamps sizes of 100-200-300-500 and 750 watts. There are also some enclosed Benjamin globes used on certain units around pickling vats. Also flood lights for sign lighting furnished by the Electric Service Supplies Company. Cooper-Hewitt mercury lamps are used in the Inspection Department, as shown in Fig. 11. Thompson disconnecting lamp hangers are used on all Yard lights.

Mill Substation

Fig. 15 shows a general plan of this building, which is fireproof in construction and Fig. 16 shows

FIG. 8—General view of Pumping station.

FIG. 9—Showing Water Treating Plant.

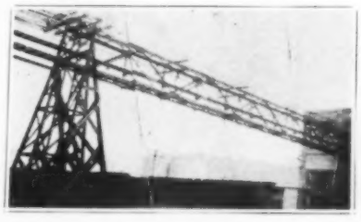


FIG. 10—Structural Steel Bridge which carries main power and steam lines.

a view of the equipment located there. The substation is centrally located and is the receiving end for the circuits mentioned under Power Plant. This substation contains the following:

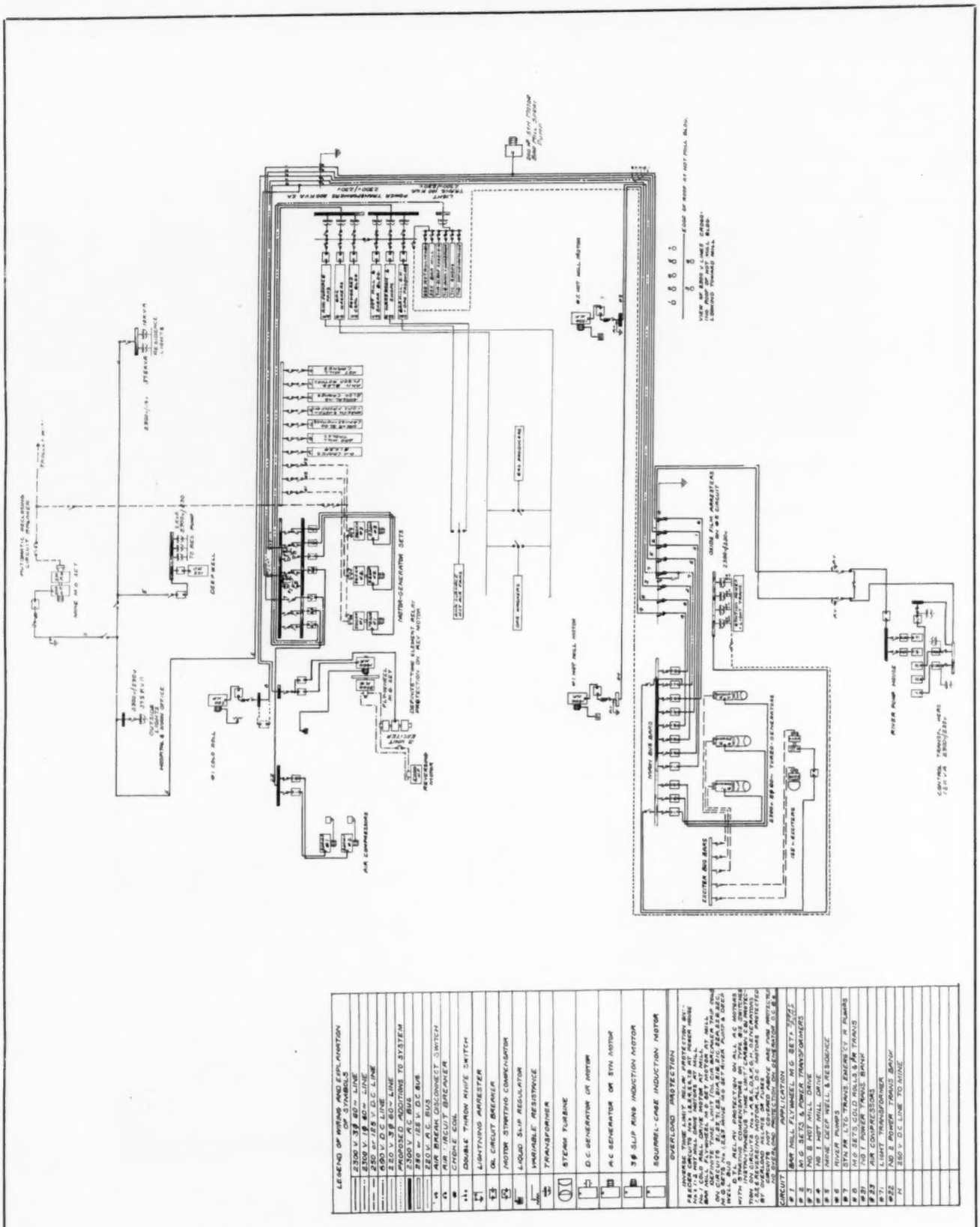


FIG. 12—Single line diagram, showing main power circuits.

MAIN SWITCHBOARD

This is a 14 panel switchboard which controls transformer banks, motor generator sets, air compressor motors, direct current and alternating current feeders to stationery motors and cranes in the mill, 2300 V. feed from panel No. 10 at the Power Plant, known as circuit No. 2, is connected to a double bus system on this switchboard. Also feeder from panel No. 17 at the Power Plant, known as feeder No. 8, can be connected to the same bus in case of emergency, so that either of the loads mentioned can be connected to either bus or feeder.

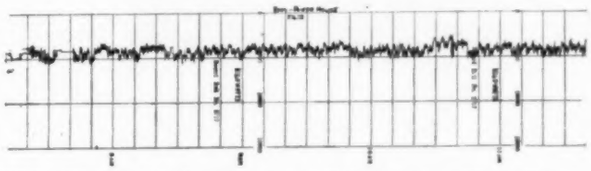


FIG. 13—Chart taken from totalizing meter, Main Power Plant.

General Electric 500 amp. F.K.-7500 V. DT oil switches with overload relays are used for tying in the buses at the Substation. Fig. 17 is a view of this switchboard.

Panels Nos. 1 and 2 are marked transformer bank No. 1 and air compressor feeder and contain the following:

1 Power factor switch
1 Type O.A. polyphase watthour meter.
1 Type R.S. 3 phase ammeter switch with key.
1 Cover plate and handle for oil circuit breaker mounted remote.
Cover plate and handle for oil switch mounted remote.
1 200 amp. 4500 V. 2 P.S.T. type F-1 hand operated automatic remote control pipe frame mounting oil switch with inverse time element attachment.

FIG. 14—Finished Sheet Inspection, indicating one of the methods by which Follansbee Forge Quality is maintained.

2 400 amp. 7500 V. S.P.S.T. FC disconnecting switches.
1 20/1 potential transformer.

Panel No. 4. This is No. 1 generator synchronous motor panel with the following equipment:

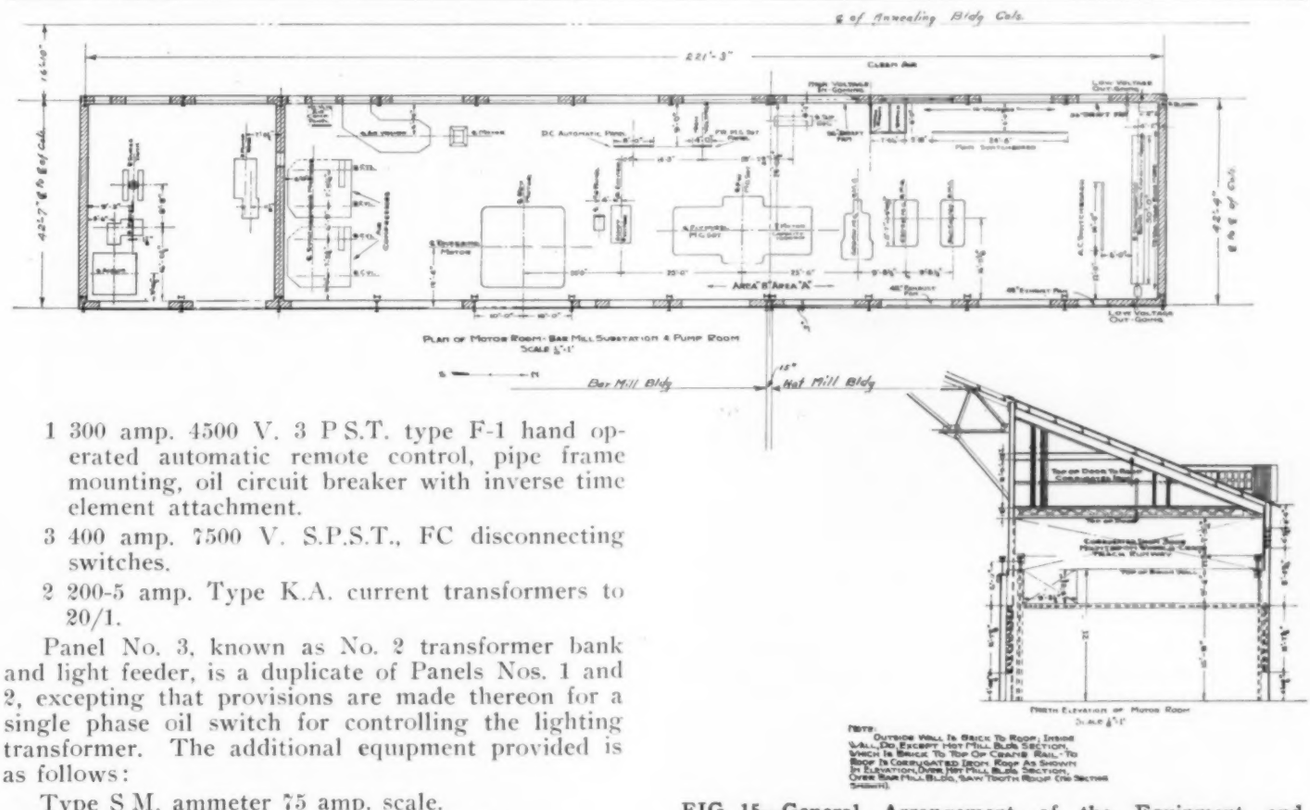


FIG. 15—General Arrangement of the Equipment and Buildings, of Main Motor Room and Substation.

1 300 amp. 4500 V. 3 P.S.T. type F-1 hand operated automatic remote control, pipe frame mounting, oil circuit breaker with inverse time element attachment.
3 400 amp. 7500 V. S.P.S.T., FC disconnecting switches.
2 200-5 amp. Type K.A. current transformers to 20/1.

Panel No. 3, known as No. 2 transformer bank and light feeder, is a duplicate of Panels Nos. 1 and 2, excepting that provisions are made thereon for a single phase oil switch for controlling the lighting transformer. The additional equipment provided is as follows:

Type S M. ammeter 75 amp. scale.
Type O.A. single phase watthour meter.

Type S.M. ammeter, 300 amp. scale.
Type S.L.D.C. field ammeter.
1 O.A. watthour meter.
1 8 point voltmeter receptacle.
1 Field rheostat mechanism.
1 Cover plate and handle for starting equipment mounted remote.

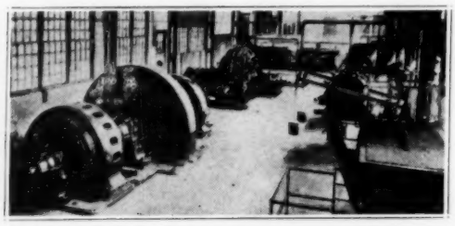


FIG. 16—30-inch Reversing Sheet Bar Mill, Motor Equipment.

1 300 amp. 4500 V. 3 F.S.T. type F-1 hand operated automatic remote control pipe frame mounting oil circuit breaker with low voltage release auxiliary switch and sequence interlock, and inverse time element attachments for running side.

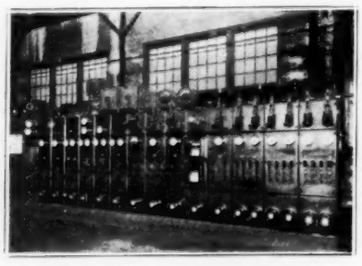


FIG. 17—A. C. and D. C. Switchboard, located at Substation.

2 300 amp. oil circuit breakers, duplicate of the above, non-automatic for starting purposes.
2 300-5 amp. type KA current transformers.
2 20/1 potential transformers.
1 200 amp. 2 P.S.T. field switch.

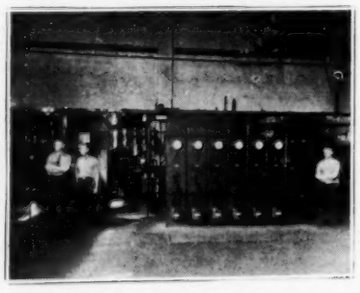


FIG. 17A—A. C. Switchboard and Substation.

Panels Nos. 5 and 6. (Nos. 2 and 3 motor generator set synchronous motors) each contain the following:

1 Type S.M. AC ammeter 160 amp. scale.
1 S.L. DC field ammeter.
1 S.I. polyphase power factor meter (for use on all three motors.)
1 Type O.A. polyphase watthour meter.
1 Power factor switch.
1 4 point meter plug.
1 Rheostat mechanism.
2 Cover plates and handle for starting equipment mounted remote.

This starting equipment is a duplicate of Panel No. 4.

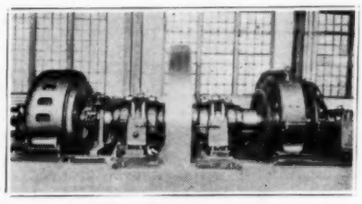


FIG. 18—Fly Wheel Motor Generator Supplying Power to Single Unit Reversing Motor Driving 30″ Sheet Bar Mill.

Panel No. 7 No. 1 motor generator set generator panel containing the following:

1 3000 amp. S.P. automatic carbon circuit breaker.
1 DC ammeter, 4000 amp. scale.
1 4 point voltmeter receptacle.
1 Rheostat mechanism.

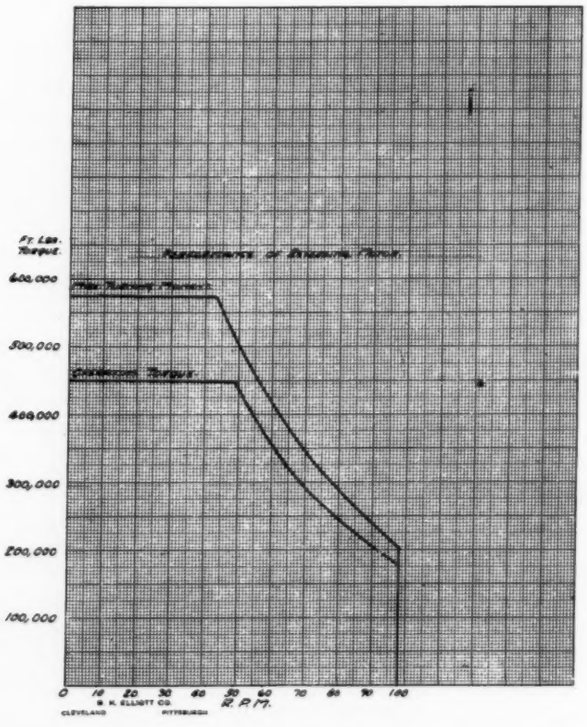


FIG. 19—Curve showing performance of 30″ Mill, Reversing Motor.

2 3000 amp. S.P.S.T. knife switches.
1 2000 amp. Sangamo watthour meter.
1 Type D reverse current relay.
1 S.L. voltmeter 300 V. scale.

Panels Nos. 8 and 9. Nos. 2 and 3 M.G. set generator panels containing the following:

1 1600 amp. S.P. automatic carbon circuit breaker.

1 Type S.L. DC ammeter, 2500 amp. scale.
1 4 point voltmeter receptacle.
1 Field rheostat mechanism.
2 1600 amp. S.P.S.T. knife switches.
1 1200 amp. Sangamo watthour meter.
1 Type D reverse current relay.

Panel No. 10. Meter panel containing the following:

1 Type M graphic recording ammeter with 6000 amp. scale.
1 Type M graphic recording voltmeter, 300 V. scale.
1 3000 amp. 2 wire Sangamo watthour meter.

Panel No. 11. Open Hearth Crane feeder panel containing the following:

1 1600 amp. S.P. carbon circuit breaker.
1 DC ammeter, 2500 amp. scale.
2 1600 amp. S.P S.T. knife switches.
1 1500 amp. Sangamo watthour meter.

Panels Nos. 12, 13 and 14. Feeders to Bar Mill tables, Shear Building, Cranes and Motors, Warehouse and Shops, Open Hearth and Gas Producers, Annealing Floor Cranes and Motors and Sheet Mill Cranes, containing the following:

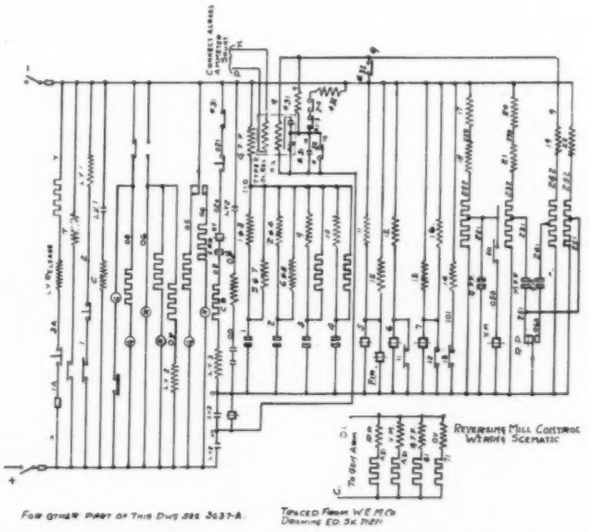


FIG. 19A—Schematic wiring diagram showing 30" Reversing Mill Control.

800 amp. S.P. carbon circuit breakers.
DC ammeter with 1200 amp. scale.
800 amp. S.P.S.T. knife switches.
800 Sangamo watthour meters.
The above are double circuit panels.

Low Tension Switchboard on Power Transformers. This is a seven panel switchboard for controlling out-going 3 phase, 230 V. power and 1 phase, 220 V. light feeders to stationary motors and lights in the mill.

Panels Nos. 1, 2, 3 and 4 containing the following equipment:

Type S.M. ammeter, 1200 amp. scale.
Type R.S. ammeter switch.
Cover plate and handle for oil circuit breaker mounted remote.
Type O.A. watthour meter, 200 V. coils.
800 amp. 4500 V. 3 P.S.T. F-3, hand operated automatic remote control pipe frame mounting oil circuit breaker with inverse time element attachment.
800—5 type FB current transformers.
1200 amp. 7500 V. S.P.S.T. FC disconnecting switches.

Panels Nos. 5 and 6.

Type S.M. ammeter, 900 amp. scale.
Ammeter switch with key.
O.A. watthour meter.

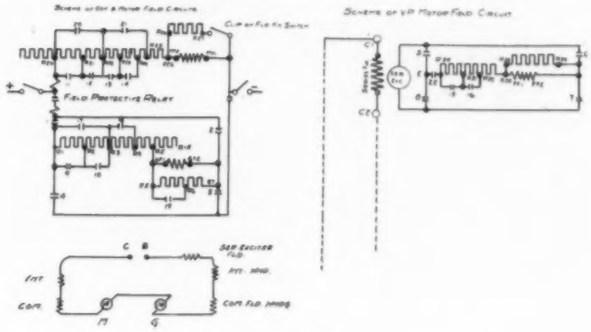


FIG. 19B

Cover plate and handle for oil circuit breaker mounted remote, 600 amp. 4500 V. 3 P.S.T., type F-2 hand operated remote control, pipe frame mounting with inverse time elements attachment.
600—5 amp. current transformers.
800 amp. 7500 V. S.P.S.T. FC disconnecting switches.

Panel No. 7. This is the lighting panel for distribution of the various light circuits to the plant and contains six 200 amp. 2 P.S.T. fuse knife switches with fuse mounted on the rear of the panel. Both of the above switchboards were furnished by the Westinghouse Electric & Manufacturing Company. Fig. 17-A shows view of AC switchboard and power transformers.

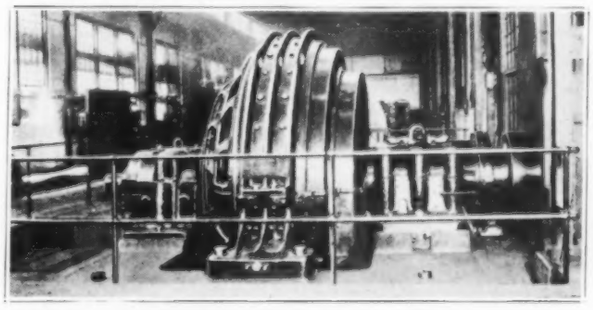


FIG. 20—Single Unit Reversing Motor Driving 30" Sheet Bar Mill.

Transformers

Power at 230 volts A.C. for stationary motors throughout the plant is furnished by 2 banks, each containing three 200 K.V.A. 2300 V.—230 V. OISC type A single phase, Packard transformers. All transformers are exact duplicates, and switching is so arranged that both banks can be operated in parallel, or any individual transformer disconnected from the others in case of failure.

This is also a Packard transformer furnishing lights throughout the plant and yards.

Motor Generator Sets

There are three motor generator sets installed for furnishing power for direct current stationary motors and cranes.

Motor generator set No. 1 is 500 K.W. 250 V. direct connected to 720 H.P. synchronous motor, 900 R.P.M. 80% leading power factor with a direct connected 6½ K.W. exciter. All of Westinghouse manufacture.

Nos. 2 and 3 M.G. sets, General Electric, 360 K.W. 250 V. direct connected to 420 K.V.A. 80% power factor, 1200 R.P.M. synchronous motors. M.G.

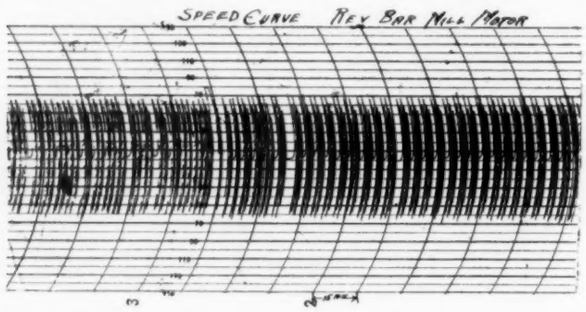


FIG. 21—Speed Curve taken from 30" Reversing Sheet Bar Mill Motor.

sets Nos. 1 and 2 are operated in parallel normally, while No. 3 is maintained as a spare and is also used for furnishing power to the Coal Mine in an emergency, on a grounded system.

BAR MILL REVERSING EQUIPMENT

This equipment drives a 30 inch reversing Bar Mill used in rolling sheet bar. A description of the Bar Mill will be given later. The electrical equipment consists of the following:

Main Switchboard

It consist of three panels and contains the following:

1 Esterline speed indicator.
Type S.M. indicating wattmeter.
Type O.A. watthour meter.
Type S.L. DC voltmeter 0-750-0-750 V. scale.
1 DC ammeter 10000-0-10000 amp. scale.
1 Lincoln Demand meter.
2 4 point voltmeter receptacles.
1 Type A field switch, 300 amp. 2 P.S.T. for VP.
1 Type A field switch, 300 amp, 2 P.S.T.
1 Two handle cover plate for breaker mounted remote for fly wheel motor generator set with two direct trip attachments.
Mechanical interlocks holding out coils and low voltage release coils.
1 Two handle cover plate for starting equipment on three unit exciter set and ventilating fan motor with two direct trip attachments, overload coils mechanical interlock, and low voltage release and lockout coils.
4 Type C.O. overload relays—2 each for Flywheel M.G set and extra set.
1 Type F-2 oil circuit breaker, 500 amp. 7500 V. 3 P.D.T. remote control full automatic for flywheel motor generator set.
1 Type Q.F. auto starter switch 600 amp. 4500 V., 4 P.D.T. remote control for three unit exciter and ventilating fan motor.
3 Type P. disconnecting switch, 600 amp. 7500 V., S.P.S.T. with latches and steel bases.
4 Type K.A. current transformers 600-5 amp.
2 K.A. current transformers 300-5 amp.
4 Potential transformers 20-1.
1 Potential transformer 1½ KVA for slip regulator NV release.

Fly Wheel Motor Generator Set

This set consists of one 1650 K.W. 50°C. 700 V. 500 R.P.M. DC generator, direct connected to a 60,000# plate flywheel 12' in diameter and one 1600 H.P. 50°C. 2200 V. 3 phase, 60 cycle, 14 pole wound rotor induction motor with 1 #4 liquid slip regulator. Fig. 18 shows a view of this flywheel set.

Reversing Motor

This is a 700 V. DC reversing steel rolling mill motor 2000 H.P. continuously at 50 R.P.M., with provisions made for obtaining a speed of 100 R.P.M., with forced ventilation of 20,000 cu. ft. of air per minute, 50°C. Fig. 19 shows the maximum torque available under different conditions. Both the generator and motor are of the compensated commutating pole type arranged for separate excitation.

Fig. 19A shows wiring schematic on reversing equipment.

Fig. 20 shows Reversing Motor.

Fig. 21 shows chart of Reversing Motor speed.

Fig. 22 shows chart of KW input to F.W. set.

Fig. 23 shows chart of Demand on Reversing motor.

Fig. 24 shows Reversing motor control switchboard.

Three Unit Exciter Set

This consists of a constant voltage generator for furnishing excitation on the reversing motor and D.C. generator and a variable voltage generator for furnishing compounding effect on the reversing motor. The constant voltage generator is 25 K.W.,

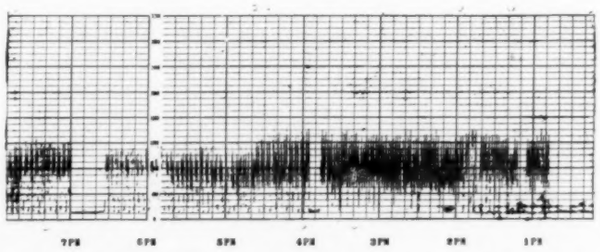


FIG. 22—Watt Meter Chart taken from 30" Sheet Bar Motor.

125 V. 1160 R.P.M. 50°C. The variable voltage generator 7½ K.W. 50°C. 125 V. 1160 R.P.M. both direct connected to squirrel cage induction motor, 50 H.P. 2200 V. 1160 R.P.M.

Ventilation

Ventilation is furnished for the reversing motor by a 20,000 cu. ft. blower and air washer, manufactured by B. F. Sturtevant Company with re-circulating pump with provisions made for taking air from inside or outside of the building. The blower is driven by a Westinghouse 30 H.P. 2200 V. induction motor, which is controlled from the type Q. F. starter mentioned in connection with the three unit exciter, and is interlocked electrically so that in case of failure of the air, the exciter set is shut down.

Reverse Motor Control Switchboard

This switchboard consists of four panels with necessary magnetic switches, relays, etc., see Fig. 24, to control the rate of acceleration and retardation of the motor and consists essentially of the well known Ward Leonard system of control, well known to steel mill engineers and which does not require elaborate description at this time. However, a complete description of this drive has been written by the writer, and may be obtained upon application.

Tie Panel Circuit Breaker

This is an electrically operated high capacity automatic circuit breaker connected between the motor and generator arranged to operate in case of severe overload, and is hand re-set. The operator's pulpit is located at the mill and contains master switch and small switchboard panel with indicating type D.C. voltmeter, speed indicator, ammeter, stop push button and signal lights. All control wiring is run in steel conduit between the master switch and equipment in the substation. All direct current buses between flywheel set generator and reversing motor are mounted on Westinghouse pillar type insulators in suitable trenches in the floor of the substation and covered over with steel plates as may be seen from the pictures. All incoming high tension lines are

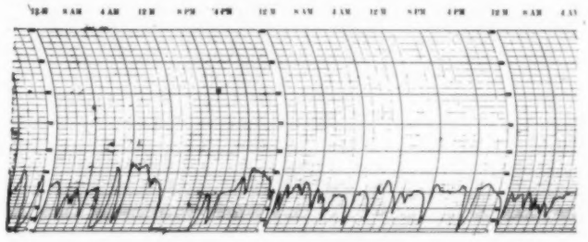


FIG. 23—Demand meter chart reading, taken from a 30" Reversing Driving Bar Mill.

run in fiber conduit, encased in concrete, and all outgoing feeders, low tension, are installed in the same manner. Ventilation of the substation is provided by Ilg fans and steam is used for heating. Crane service may be had from an adjacent building by means of a portable end on the substation building.

Air Compressors

Two Bury air compressors, 1000 C.F P.M. capacity, are also located in this building for furnishing compressed air for the plant and are direct connected to 200 H.P. synchronous motors, 2200 V. 3 phase, 60 cycle, 250 R.P.M. 80% leading power factor, belted to 7½ K.W. 125 V. exciters, 750 R.P.M., with two panel switchboard consisting of the following:

1 Line ammeter.
1 Field ammeter.
1 Field switch.
1 Field rheostat mechanism.
1 Type Q.F. starting switch complete with automatic overload.
Inverse time element attachment and low voltage release.
Necessary current and potential transformers, etc.

All of the above equipment is of Westinghouse manufacture, except as noted. A double air compressor unit consisting of two 500 C.F.P.M. units to be driven by synchronous motors are to be installed here shortly. An attendant on three 8 hour shifts is employed in the substation.

OPEN HEARTH DEPARTMENT

This Department contains four 50 ton Open Hearth furnaces arranged for natural gas, producer gas or oil fuel. Fig. 25 shows a general view of the furnaces from the charging side. Pig iron, sheet

Fig. 24—Primary and Field Control Panels for 30" Reversing Sheet Bar Mill Motor Equipment.

scrap, etc., is stored in the stock house adjacent to the Open Hearth buildings, and this material is hauled by Fordson tractor with special flanged wheels operated on 60# steel railway system to the furnaces. Wellman, Sever Morgan cars and charging boxes are used in the train in the usual manner. Steel is poured into molds on cast iron ingot stools at the steel plant as shown in Fig. 26 which is a view of this Department Ingots are 14"x14"x4' 8" and weight about 3000 lbs.

Cranes. A 10 ton single hoist Alliance crane equipped with 50" Ohio magnet is operated in the Stock-

FIG. 25—Charging Machine used in connection with Open Hearth Furnaces.

house. This crane is provided with E.C.&M. crane protective panel and type G and Dinkey controllers. Westinghouse M.C. 37 H.P. motors are used on Hoist and bridge and 7½ H.P. on trolley. Type H cast grid resistance and E.C.&M. electric shoe brakes are used on this crane.

An Alliance overhead type charger is used for charging the furnaces, as shown in Fig. 25, and is

equipped with E C.&M. protective panel, G and Dinkey controllers. 27 H.P. MC motors are used on bridge trolley and hoist and 15 H.P. on peel. Brakes and resistance are the same as on Stockhouse crane.

An Alliance 10 ton crane, an exact duplicate of the one used in the Stockhouse is used on runway directly over the charging crane.

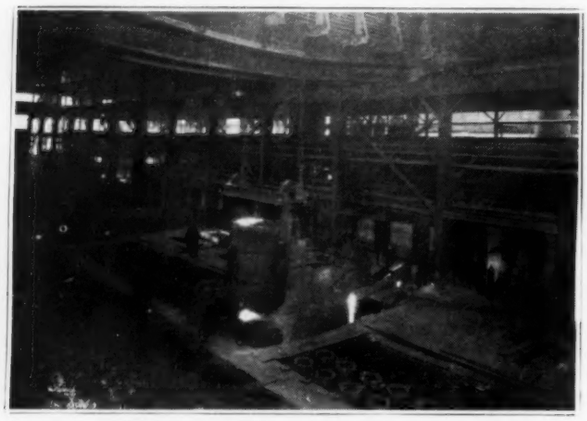


FIG. 26—Pouring Platform showing Ladle Crane in Operation.

The steel plant contains the following cranes:

1 Double hoist Alliance crane.

20 ton main and 10 ton auxiliary provided with E.C.&M. control panel and G. and Dinkey controllers and Westinghouse motors.

Main hoist motor, 65 H.P. trolley, 15 H.P. bridge and auxiliary hoist 37 H P. each. The small hoist of this crane is equipped for 50" Ohio magnet to operate skull cracker for breaking slags, and the main hoist is used for pulling slag and operating single line bucket.

The ladle crane is an Alliance 75 ton, four girders with main and auxiliary trollies. E.C.&M. crane

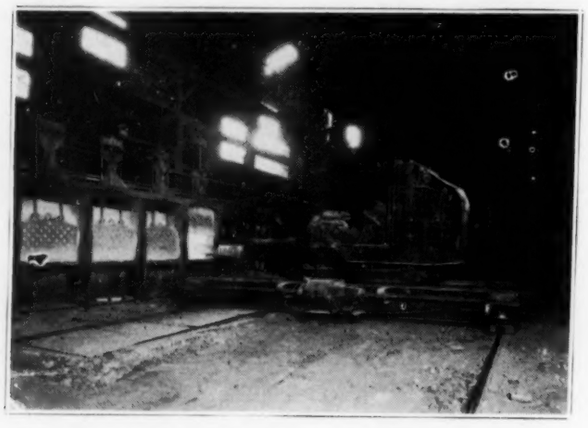


FIG. 27—Heating Furnaces, showing Method of Charging Furnaces.

protective panel switchboard with type M.S. duplex full magnetic controller on the main hoist and full magnetic controller on the bridge, and type H masters on both bridge and hoist. Motors are Westinghouse M.C. as follows:

Main hoist, two 88 H.P. each.
Bridge, one 88 H.P.
15 H.P. on main trolley.
Auxiliary trolley, 7½ H P.
Auxiliary hoist 37 H.P.

Provisions are made on this crane switchboard to cut out one of the hoist motors in case of failure while the remaining motor has sufficient capacity to operate the hoist in an emergency. The remaining controllers on this crane are type G and Dinkey controllers. Fig. 26 shows view of the crane. Nichols Lintern Sanders are used on the bridge of this crane.

The other cranes in this department are duplicates of the double hoist crane on slag handling, except that the main hoist is 25 ton capacity and small hoist is the same capacity but much faster. Electrical equipment is the same as slag handling crane. This crane is used for stripping ingots and piling them.

Some of the stationary motors in the Open Hearth consists of 20 H.P., 3 phase, 60 cycle, 220 V. Westinghouse motor driving Mud Mixer and 5 H.P. driving blower on Blacksmith shop forge 10 H.P. Wagner vertical motor driving sump pump, etc.

FIG. 28—View of 1000 Ton Press, and Forging Manipulator.

The Open Hearth valves are manufactured by Morgan Construction Company, Isley patents and are driven by 5 H.P. General Electric 1804 compound wound motors and General Electric CR-4892 magnetic controllers provided with dynamic braking with push buttons located at each furnace.

Gas Producers and Washers. The Gas Producers are located near the Open Hearth and consist of 8 Hughes Producers each driven by 5 H.P. 230 V. Squirrel cage motor, 870 R.P.M. and a 35 H P. squirrel cage motor 575 R.P.M. driving a coal crusher which receives coal from railroad cars through a suitable hopper. After the coal is crushed it is distributed by a Milwaukee electric crane and grab bucket to the respective bins over the producers. This crane has a main switchboard E.C.&M. with 65 H.P. Westinghouse motor on main hoist, 37 H.P. motor on auxiliary hoist and 15 H.P. on trolley.

Part of the gas produced here is used in Dressler Annealing furnaces, (which will be discussed later), and is cleaned in gas cleaning plant containing 3 exhausters, each driven by 75 H P. induction motors

870 R.P.M. All motors and controllers in this department are Westinghouse manufacture.

Chemical Laboratory. A fully equipped Chemical Laboratory is also maintained at the Open Hearth and contains a crucible furnace, electric still, muffle furnace, drill press, and complete photographing outfit. All of the above is operated on single phase, 220 V. 60 cycle current. Drill press is operated by 5 H.P. Westinghouse type A.R. motor. This laboratory is heated by Cutler-Hammer heating units, 220 V. direct current.

A Browning locomotive crane is used in the yard equipped for 50" Ohio magnet, and is also used for spotting railroad cars and distributing coal by means of grab bucket.

INGOT FURNACES AND BAR MILL

The Ingot Furnace Department contains 4 direct heating type furnaces for re-heating ingots and takes the place of the usual soaking pit type of furnace. Powdered coal fuel is used on these furnaces with storage bins located near by. The coal hoppers are driven by 2 H P. SK 500-200 R.P.M. motors, totally enclosed, and the coal is blown in the furnace by Spencer Turbo Blower direct connected to 3 H.P.

FIG. 28A—View of 1000 Ton press, and Forging Manipulator.

Wood Machine Company induction motors totally enclosed. Fig. 27 shows view of these furnaces with Alliance charger which is of the floor type provided with E.C.&M. panel G and Dinkey controllers, Westinghouse motors 27 H.P. on hoist. Two 15 H.P. motors in series on trolley, 15 H.P. motor on the tongs and a 37 H.P. motor on the bridge, and 15 H.P. on revolving trolley.

Bar Mill. Figs. 28 and 28-A show view of 1000 ton United Engineering & Foundry press and Alliance Machine Company forging manipulators. This press is used to forge the ingot to a 6½"x6½" billet and the manipulator cranes are used to handle it during the forging process. The press is operated by hydraulic and steam pressure. The ingot is transferred from the charger by means of an ingot table driven by Westinghouse 15 H.P. M.C. motor and E.C.&M. magnetic controller controlled by push button located in the crane cab on one of the manipulators and operated by the manipulator operator. The manipulator operator runs the ingot into the tongs of this crane after which he takes it to the press for the forging operation. The ingot during the forging is passed back and forth and turned by manipulators,—one on either side of the press, and when a finished bloom, is delivered to the Bar Mill by one of the manipulators.

The manipulator cranes are Alliance equipped with E.C.&M. crane protective panels, G and Dinkey controllers and Westinghouse motors as follows:

Hoist, 7½ H.P. MC.
Bridge, two 27 H.P. type K. motors in series.
7½ H.P. MC on tongs, rotating motion.
7½ H.P. MC on rotating trolley.

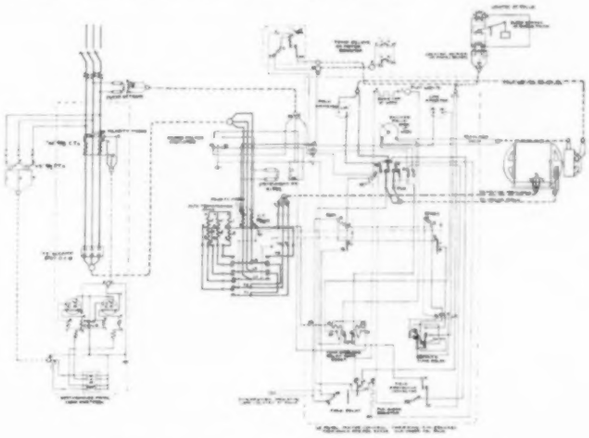


FIG. 29—Wiring Diagram Spray Pump.

The tongs used for gripping the ingots are operated by air furnished from the mill air line. The tongs rotating motions on these manipulators use E.C.&M. type Q. brakes.

A triplex pump for hydraulic system on this press is driven by a 20 H.P. squirrel cage motor, 870 R.P.M. This is also a 100 H.P. squirrel cage induction motor, 575 R.P.M. driving a triplex pump located in this department.

FIG. 30—Main Motor Driving—2 High Sheet Mill Stands, 4 Rough and 4 Finishing.

30" Reversing Bar Mill. This is a two-high 30" Bar Mill manufactured by the National Roll & Foundry Company driven by 2000 H.P. reversing motor mentioned in description of substation equipment. The mill rolls 6½"x6½" billets into sheet bar 8" wide in 7 passes. The thickness of finished bar varies from 5/16" to 1¼". The operator's pulpit is located directly over the mill main rolls. There are

two operators in this pulpit; one operates the reversing motor and mill table motors and the other operates the hydraulic manipulators on the mill. A foot operated master switch for the reversing motor was considered with the hope of eliminating one of the operators, but the close variation in motor speeds required, makes its success doubtful up to the present time. The approach table on this mill which receives the billet from the forging crane consists of 10 table rolls 12" in diameter, driven by Westinghouse 27 H.P. MC motors, series wound, connected through a back shaft to table line shaft. The motor is controlled by Dinkey controller located in the pulpit. The front and back tables on the mill each consist of fifteen 12" rolls, each driven by 65 H.P. MC Westinghouse motor with back shaft and gearing to table line shaft. The control for these motors

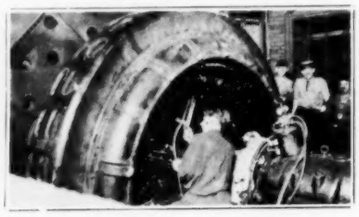


FIG. 31—View of Main Motor during an Annual Inspection.

consists of two 60 H.P. E.C.&M. magnetic switchboard with type H resistance and type B master switches. The master switches are mounted on the pulpit and interlocked mechanically.

The gear ratio is 5½ to 1 double reduction and the roll speed is 100 R.P.M., or a surface speed of about 350 per minute.

After the sheet bar leaves the last pass, it is manipulated over a cooling bed to a shear table driven by 65 H.P. MC motor with 40 H.P. Dinkey controller located near a bar shear and operated by the shearmen. The bars pass from this table to the bar shear to be cut in required lengths. The bar shear is manufactured by McIntosh-Hemphill with 8 ton flywheel driven by 25 H.P. type SK motor, 400—1200 RPM and E.C.&M. 25 H.P. magnetic controller with field rheostat and relay and master switch located near the 40 H.P. Dinkey controller for the shear table.

Spray Pump. A high pressure centrifugal pump unit manufactured by Worthington Pump & Machinery Company, direct connected to 200 H.P. General Electric synchronous motor, 1800 R.P.M. with full automatic control is used for furnishing water at high pressure on each pass on the main rolls of the mill for the purpose of cleaning the billet as it goes through each pass. This motor is of a special drip-proof construction for pump service and is 2300 V. 3 phase, 60 cycle, 80% leading power factor with direct connected exciter. The control is General Electric full automatic CR 7061-S-1 provided with ammeter for motor, field ammeter power factor, meter, exciter field rheostat mechanism, start and run contactor oil immersed, field contactor, temperature overload relay, and transfer relay, starting compensator, push button station, etc. The motor is also provided with type TB-2 bearing relays, Fig. 29 shows wiring schematic used. This pump is controlled by Westinghouse feeder panel upon which is mounted the following:

1 Type O.A. watthour meter.
2 Type C.O. overload relays.
1 Cover plate and handle with direct trip attachments for oil circuit breaker, mounted remote on pipe frame work 600 amp. 3 pole, single throw, 4500 V. type F-2.
3 400 amp. 7500 V. 3 P.S.T. type P disconnecting switches.
3 Auto valve lightning arrestors.
Necessary current and potential transformers, etc.

An Alliance traveling crane is located in this department and is an exact duplicate, electrically and mechanically of the one used in striping ingots at the Open Hearth Department.

SHEET MILLS

Reference to Fig. 1 will show that the Open Hearth, Ingot Furnaces, Bar Mill and Sheet Mill buildings adjoin each other. The Sheet Mills contain two roll trains as follows:

No. 1 Drive, consists of eight 50" National Roll & Foundry, two high Sheet Mill stands,—four rough and four finish,—driven from the middle by a 1500 H.P. 2300 V. 3 phase, 60 cycle, 240 R.P.M. 35°C. Allis Chalmers wound rotor induction motor with 25% overload capacity continuously at 50°C. rise.

The gear unit is manufactured by the Falk Corporation and consists of a helical pinion mounted on the high speed shaft connected through a Franke flexible coupling to the motor shaft and a large gear mounted on the mill spindle. This spindle is provided with separate bearing and thrust collars and is

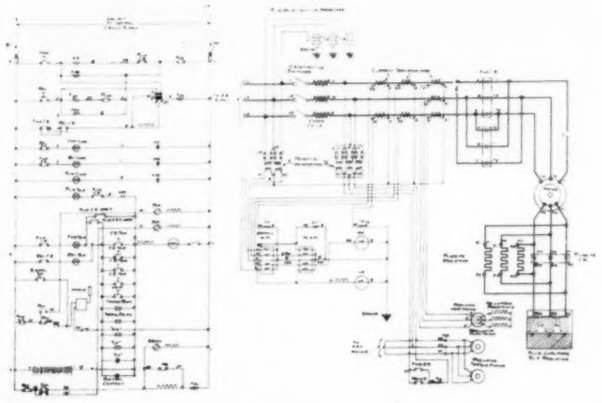


FIG. 32—Single Line Diagram showing Full Automatic Control of 2—1500 HP Hot Mill Motors.

connected to the roll train through the short connecting spindles, boxes, etc., on each side of the drive.

The roll speed is 27 R.P.M. The gear unit is totally enclosed by cast iron case filled with gear shield lubricant. The high speed pinion shaft also carries two flywheels, 25 tons each, enclosed by guards for equalizing the peaks on the motor in connection with the slip regulator located in the control room. Fig. 30 shows view of the drive and Fig. 31 shows view of the motor during the annual inspection.

Primary Control. The primary controller for this unit consists of the following:

1 Westinghouse switchboard upon which is mounted the following:

1 Indicating voltmeter and ammeter.
1 Watthour meter.
1 Esterline graphic wattmeter.
2 Type C.O. overload relays.
1 Type CV relay.
3 Push buttons, forward, stop and reverse.

And the following is mounted remote from the panel:

2 Type B-13 oil circuit breakers, 1200 amp. 15000 V. 3 P.S.T. arranged for pipe mounting, electrically operated for 230 V. DC closing coil and 24 V. DC triple coil with 5 P.D.T. 90° knife type auxiliary switches.
3 Type S disconnecting switches 7500 V. 600 amp.
2 Type KA current transformers 500-5 amp.
2 Type K current transformers 400-5 amp.
2 Type Vs potential transformers 20-1.
1 20 ampere hour 24 V. storage battery for tripping.
1 Battery charging panel including knife switch, rheostat and ammeter.
1 Slate panel for mounting relays for controlling circuit breakers on which is mounted the following:
  5 Type 30 C. contactors.
  1 Type KT time element relay for circuit breaker trip free.
  1 Type KT time element relay for glazen alarm circuit.

Secondary Control. The secondary control consists of Allis Chalmers slip regulator with sufficient Cutler Hammer resistance mounted separate to limit plugging current to 125% of motor full load current. A Westinghouse type B-13 oil circuit breaker, a duplicate of the two mentioned for the Primary Control, is used for cutting this resistance in and out of circuit. Reference to Fig. 32 shows complete wiring diagram of the control. Three 10 KVA 2300 V. to 230 V. single phase, Packard transformers are located in this control room for furnishing power to the slip regulator pump and air washer motors. It will also be noted from this control diagram that provisions are made to prevent operation of the motor without ventilating air. The mill motor is totally enclosed and provisions are made to furnish 12000 cu. ft. of clean air, which is taken from the outside of the building to the motor through air ducts encased in concrete. A Spray Engineering washer with recirculating water pump and clarage fan direct connected to 15 H.P. 870 R.P.M. motor is used for this purpose. Cutler Hammer space heaters are used to heat the control room and Franke coupling lubricants in cold weather. Also heaters are installed in the motor pit with a tarpaulin which is always placed on the unit when not in service.

This drive is somewhat overloaded because of the method of rolling which is somewhat different from the average sheet mill. In the well known "tight mill" method of rolling, the mill consisted of a rough and finish stand, with one crew who first rolled iron on the roughing stand and then transferred it to the finishing stand to be finished. Thus, having the actual rolling operation occur on only one stand at a time. While in our sheet mill we have the "loose rolling" method and have a crew on the roughing mill continuously and a crew on the finishing mill continuously. This introduces continuous rolling loads on both stands. It is doubtful whether flywheels are of much use on load conditions of this kind, which it will be noted is of a rather continuous character by observing Fig. 33 which is a chart taken from Esterline wattmeter. However, some of this is due to the fact that it was necessary to raise the setting on the slip regulator somewhat beyond its normal limits on account of this load condition. One of the mills on this train is a balanced rougher with screws operated by a screw-down motor, Westinghouse M.C. 15 H.P. with Cutler Hammer brake, Cutler Hammer limit switch and E.C.&M. magnetic control with type B master switch and type H resistance. The control is mounted on the floor near the mill.

No. 2 Drive. This drive is an exact duplicate of No. 1 Drive, except that the mills are as follows:

6 Finishing mills—three 44" and three 40".
5 Roughing mills—three 40" and two 44".

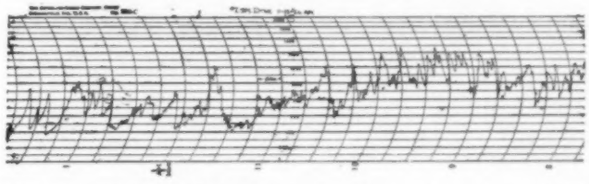


FIG. 33—Watt Meter Chart Reading taken from 1500 H.P. Hot Mill Motor.

This is a "loose rolling" proposition also and remarks made in connection with the other drive apply even more so here as the load is more severe. Stop PB's are located near the mill housings, but starting and reversing PB's are located in the control room only.

Break Down Picklers. Pickling equipment is located in this building to pickle sheets after they are roughed in the roughing mills and consist of several wood and brick vats so arranged that crates of roughed iron are set in them and washed in an upward and downward direction. Each pickling machine is driven by two S.K. 220 V. DC motors 700 R.P.M. totally enclosed, 25 H.P. with enclosed Westinghouse starter. The crates are handled by two Northern Engineering mono-rail cranes which are mounted on a stationary platform away from the pickler tubs so arranged that small trolley racks in and out on 2 I-beams with the necessary sheave wheels and cables for raising and lowering the crates in the vats. The mono-rails were formerly on single I-beams and traveled directly over the vats, but it was impossible to maintain them in this manner because of acid fumes. The Pickling Department is enclosed by a steel building lined on the inside with wood which confines the fumes to a stack directly above. Ilg ventilating and heating fan is used for removing these fumes. The mono-rail cranes have 15 H.P. MC motors on hoist and 7½ H P. motors on trolley, each with separate drums, E.C.&M. crane switchboard Dinkey and G controllers, mounted on the floor near the vats.

The bars are distributed to the mills on skids by four cranes and the roughed iron taken to and from the picklers to the mills to be finished. The cranes consist of three 25 ton double hoist Alliance cranes.

The main hoist is 25 ton and the auxiliary hoist is 15 ton. These cranes are an exact duplicate of the crane outlined in the Bar Mill Department. There is also one 15 ton single hoist Alliance crane in this Department for handling bars at the Bar Shear. This crane has E.C.M. switchboard, 65 H.P. MC motor on hoist, 37 H.P. MC motor on bridge and 7½ H.P. MC motor on trolley. Each roll train has the necessary number of heating furnaces for heating the bars before they are roughed and after the roughed sheets are pickled but before they are rolled in the finishing mills. The furnaces are arranged for powdered coal fuel. The accompanying table gives a list of some of the auxiliary motor drives in the Sheet Mills.

Shear Building. The finished sheets are sheared in squaring shears and pickled and scrubbed similar to the operation previously described, excepting that acid bath is not so strong. A mono-rail crane is operated over these picklers and is an exact duplicate of the one described for the other picklers, excepting that it travels on single I-beam in the usual manner. The pickler drives on these finishing picklers is an exact duplicate of the Break-down Picklers previously described.

Two single stand 50" cold roll drives are located in this building for roughing cold mill work. These are driven by 100 H.P. General Electric 220 V. 3 phase, 60 cycle wound rotor induction motors, 575 R.P.M. direct connected through Thomas flexible couplings to double reduction Fawcus Machine Company gear units. The controllers are Westinghouse full Magnetic forced acceleration type with push button stations located on the mill housing. See Fig. 34. This building also contains a special annealing furnace for annealing certain grades of sheets and the table rolls are driven by Westinghouse 15 H.P. SK motor, 400-1600 R.P.M. with No. 245 machine tool controller. This building contains three 10 ton

Application	H.P.	Speed	No.
Air Washer Blower	7½	870	1
Powdered Coal Feeder	5	1800	4
Blowers for furnace Powder Coal	25	1750	2
Blowers for Ventilation for employees	7.5	870	4
Breakdown pickling tanks	16½	975	2
Finishing pickling tanks	16½	975	2
Trimming and squaring shears	15	870	5
Scrubbers	7½	1160	5
Cold Roll stands	100	570	2
Blowers for ventilation of main motors on hot mills	15	870	2
Oil pressure system for pushing cars through annealing furnace—			
High pressure (Starting)	7½	400/1600	2
Low pressure (running)	5	400/1600	2
Blower for track cooling	(5	1800	4
(Annealing furnaces)	(5	1760	4
Blowers for air distributing	(7½	850	2
(Annealing furnaces)	(20	870	2
Roll lathe	25	400/1200	1
Grind stone	2.5	1350	1
Shear knife grinder	20	875	1
Roller levelers	10	870	6
Trimming shears	(7½	870	3
(Finished product)	(5	870	3
Stretcher machine	7½	870	1
Air compressor	20	870	1
Door lifting (annealing furnace)	5	850	4
Annealing furnace stokers	3	1800	4
Annealing Furnace tables	15	400/1600	1
Man Coolers	5	870	6
Annealing box straightener	7½	870	1
Air washer circulating pump	5	1800	4

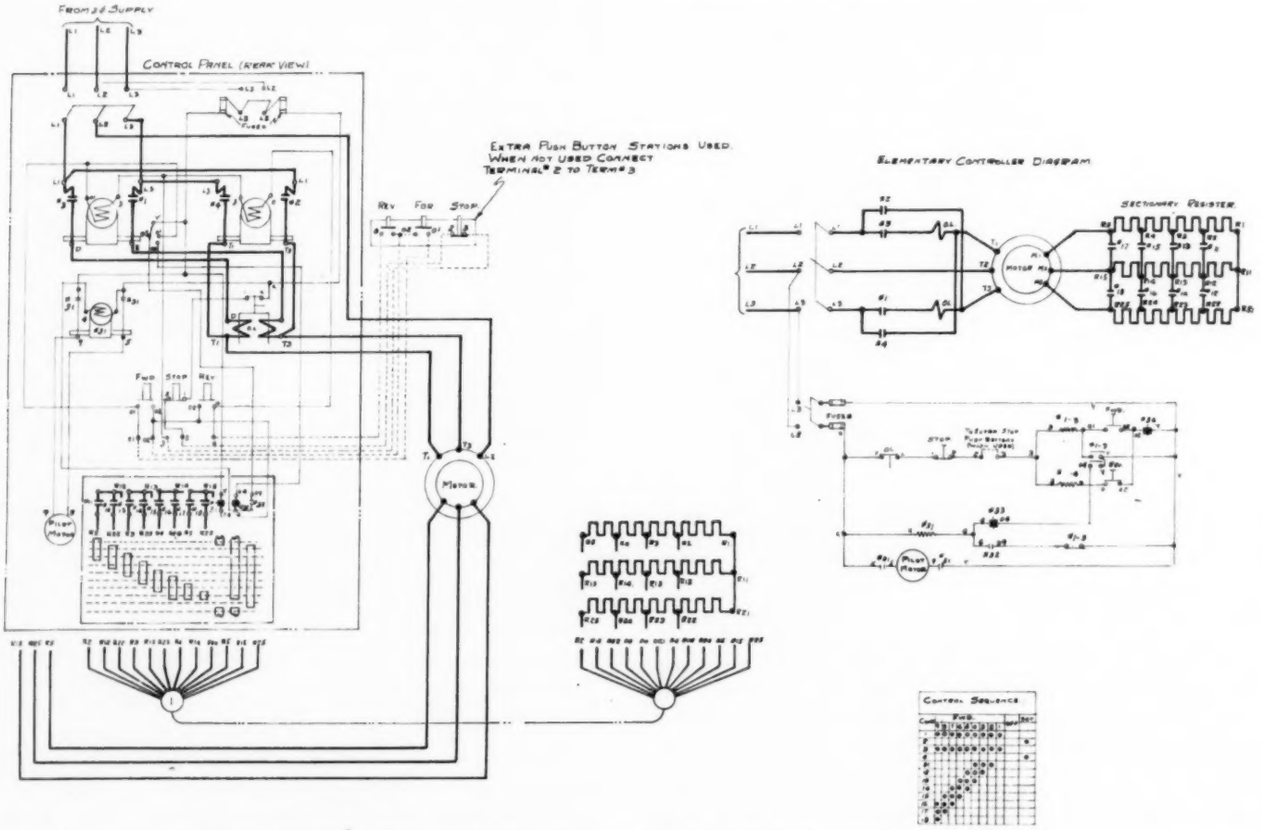

From 2 ϕ Supply
Control Panel (Rear View)
Extra Push Button Stations Used. When not used Connect Terminal 2 to Terminal 3
Rev For Stop
Fwd Stop Rev
Motor
Elementary Controller Diagram
Sectioned Resistor
Control Sequence

FIG. 34—Wiring Diagram of 100 H.P. Motor Driving 2 single stand, 50" Cold Rolls.

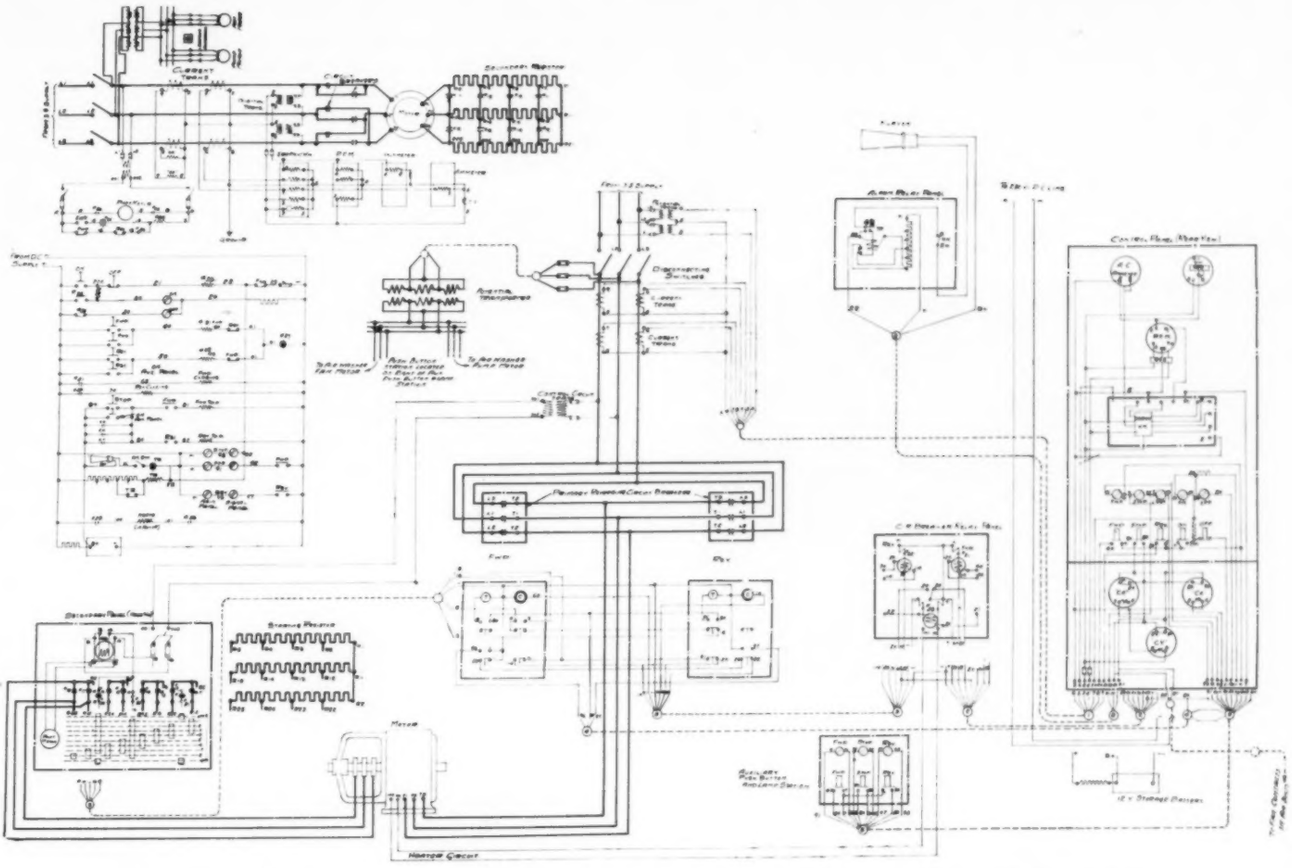


FIG. 35—Shows Diagrams of Connections of 500 H.P. Motors, Driving 8—500" Cold Rolled Stands.

single hoist Alliance cranes which are exact duplicates of the one described in the Stockhouse.

Finishing Dept. This department contains the main cold roll drive consisting of eight 50" stands driven by Westinghouse 500 H.P. 2200 V. 3 phase, 60 cycle, 440 R.P.M. wound rotor induction motor direct connected through Franke flexible coupling to double reduction Fawcus gear unit. The roll speed is 31 R.P.M. This motor is totally enclosed and air is furnished by 5000 C.F.M. clarage fan direct connected to 7½ H.P. motor, 870 R.P.M. and Spray Engineering air washer with circulating water pump. The primary control for this motor consists of a switchboard with the following mounted thereon:

1 Indicating ammeter and voltmeter.
Indicating Factor meter.
Graphic wattmeter.
2 Type CO overload relays.
1 Type CV relay.

The following is mounted apart from panel:

2 DC electrically operated type F-22, 600 amp., 4500 V. 3 P.S.T. oil circuit breakers arranged for 250 volts DC closed coil and 12 volts DC tripping coil.
3 Type S disconnecting switches, 400 amp.
2 Type KA current transformers 500-5.
2 Type FR current transformers 300-5.
2 Potential transformers 20/1.
1 12 V. storage battery with Trickell charger resistor.
1 1½ KVA transformer for secondary control.
1 Master control mounted out in the mill with the necessary stop, start and reverse push button stations and signal lights.

Secondary Control. One forced acceleration type starter with motor driven cam switch and necessary grid resistance control switch and contactor, etc. is used on this drive. Fig. 37 shows wattmeter chart taken from this motor.

There are three 5 KVA single phase Packard 2300 V. to 230 V. transformers located in the control room for furnishing power to the air washer, blower motor and pump motor. Fig. 35 shows diagram of connection on this drive and Fig. 36 shows view of the motor and mill. The motor pit is heated by space heaters and motor covered by tarpaulin when not in use. One operator on two 12 hour shifts is employed to care for this drive and the two Hot Mill drives. They also keep the washers and the units generally clean during week ends. This department also contains two Dressler Continuous Kilns, each about 350 ft. long arranged for natural or producer gas fuel. Sheets are enclosed in air tight pots and put in cars that are pushed through the furnace at slow speed by hydraulic rams which are motor driven and motors are included in representative list previously mentioned. There are also 4 box annealing furnaces in this department where boxes are put into furnaces and removed by traveling cranes. This building also contains 6 sets of roller levelers for finishing purposes. It also contains the Inspection Department as shown in Fig. 4, and also Physical Laboratory where special physical tests are

carried on in connection with the finishing process. There is a Brown Pyrometer system in use on the Dressler furnaces for temperature control at various points.

There are two Alliance traveling cranes with 40 ton main hoist and 15 ton auxiliary hoist in this department provided with E.C.&M. crane switchboard and MC motor, 65 H.P. on main hoist and bridge, 37 H.P. on auxiliary hoist and 7½ H.P. on trolleys with type G and Dinkey controllers. There is also

FIG. 36—Showing Motor Driving Cold Rolled Stands.

a 10 ton single hoist Alliance crane operating in this Department for the Cold Roll drive and is an exact duplicate of the crane in the stockhouse.

WAREHOUSE

The warehouse contains two traveling cranes exact duplicates of the one mentioned for the Cold Roll drive, together with several shears and stretcher leveler motor driven units as shown in the list previously mentioned. All shipping is done from this Department by hand truck to box cars at platform and all sheets are transferred by a transfer system in the Sheet Mills, annealing floor and warehouse buildings, as may be seen from plan view of buildings. The cars are of steel construction and contain 7½ H.P. motor and drum controllers with underground collector bar system encased in concrete and supported by insulators at different points.

POWDERED COAL PLANT

This plant is constructed of sheet steel and is as near fire-proof as possible. All coal used in the heating furnaces in powdered form is pulverized in this plant, dryed and stored and blown through pipes to individual storage bins at the furnaces. There are two pulverizers driven by General Electrfic vertical induction motors 75 H.P., 220 V., 490 R.P.M. with General Electric C.R. 1034 hand compensators. One coal elevator driven by 5 H.P. Westinghouse induction motor, 870 R.P.M. One elevator is driven by 10 H.P. 220 V. induction motor 870 R.P.M., one coal crusher driven by 20 H.P. induction motor, 870 R.P.M. and hand starter. One dryer driven by 15 H.P. induction motor 870 R.P.M. One dryer fan driven by D.C. motor SK 15 H.P. 400-1600 R.P.M. with type H starter. One transport pump driven by 20 H.P. induction motor, 870 R.P.M. with hand compensator. One Magnetic Manufacturing Company magnetic pulley for separating metallic material from coal before it gets to the crusher.

All wiring in this building is run in steel conduit as far as possible, and other fire hazards considered to a reasonable extent. A Western Electric interphone system is used from this Department to the various storage bins in the Sheet Mills and at the Ingot Furnaces.

CRANES

All motors on cranes and tables are M C. Westinghouse frames Nos. 20 to 70, except type K on forging manipulators. All crane controls is E.C.&M., also table control is E.C.&M. Conductor bars in Open Hearth, Bar Mill, Hot Mill and Annealing Floor cranes are 60# steel rails supported on General Devices and Fittings Company crane rail support insulators. All cross travel, collector bars are steel bars ⅜"x1½" supported near the bridge walkway. Collector bars ½"x2½" are used in Shear Building and Warehouse instead of steel rails. All cranes, except ladle cranes, are provided with limit switches, either of the open block type or geared E.C.&M. type. All mechanical parts such as gearing shafts, brake wheels, bushings, etc., are as near duplicates as possible. Track rails and wheels are also standardized as regards to size. There are approach ladders at various points with platforms in each building. Cutler-Hammer space heaters are used for heating crane cabs, with Square D switches. All collector rails are bonded and bonds welded at joints.

SHOPS

Tin Shop. This is a sheet metal steel building with a complete set of sheet metal workers' tools and motor driven drill press. The building is heated with steam.

Carpenter and Pattern Shop. This is a two-story brick building, steam heated. The first floor contains carpenter shop, which is equipped with the following machines:

24" National Surface planer.
Hall Brown 18" rip-saw.
12" American joiner.
24" Crescent band saw.
24" Swing saw.
American Drill press and grindstone.

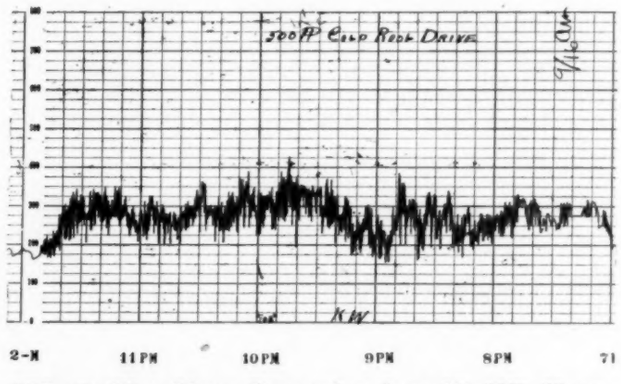


FIG. 37—Watt Meter Chart taken from 500 H.P. Motor, Driving Cold Roll Stands.

Each of the above are driven by 5 H.P. Westinghouse induction motors 1800 R.P.M.

The Pattern Shop is located on the second floor, where all patterns are made and stored. The following equipment is located there:

1 42″ American Band saw.
1 20″ Joiner.
1 12″ Rip saw.
1 24″ Oliver lathe.

Each of the above are driven by Westinghouse 5 H.P. induction motors 1800 R.P.M.

Main Storeroom. This is a brick, one story building containing all the general mill supplies, including detail spare parts for Electrical Department. The building is heated by Cutler Hammer space heaters.

Machine Shop. The general machine shop adjoins the Storeroom building and contains the following:

1 36″ American lathe.
1 24″ Queen City shaper.
1 Niles-Bement-Pond planer.
1 18″ Stamets lathe.
1 Carlton Drill press.
1 Hisey-Wolfe double wheel emery stand

The 36″ lathe is driven by 15 H.P. SK motor. 400-1600 R.P.M. with 245 machine tool controller and 7½ H.P. SK motor 400-1600 R.P.M. each on shaper and 18″ lathe and drill press, with type H controllers. The planer motor is Westinghouse SK 25 H.P. 250-1000 R.P.M. with special Niles-Bement Pond controller. This shop also has a 10 ton hand operated Whiting crane.

Blacksmith Shop. This is the general Blacksmith Shop and contains two forges with 1000# Bement-Pond trip hammer. Forge blowers are driven by Westinghouse squirrel cage motor 1800 R.P.M. A Gibb crane and special heat treating gas fired furnaces completes the equipment of this shop.

Pipe Shop. The Pipe Shop contains one Williams pipe threading machine and one Curtis & Curtis pipe threading machine, each connected to 3 H.P. induction motors, 1800 R.P.M.

Electric Storeroom. This is a brick building where large spare parts for the Electrical Department are stored with handling facilities such as I-beam trolley to transfer parts to Electric Shop, which is adjacent to it. The building is heated with Cutler-Hammer space heaters. A portion of this building is occupied by the Master Mechanic's office, and Field Engineer, as may be seen from the plan of the buildings.

Electric Shop. This building is of similar construction to the others and is steam heated and contains the following:

1 Grindstone.
1 30″ American lathe.
1 24″ Queen City shaper.
1 24″ Rockford drill press.
1 Banding machine.
1 Complete set of baking and dipping vats for electric equipment.
1 Gibb crane 2 ton capacity.

The lathe and shaper are driven by 7½ H.P. SK motors 400-1600 R.P.M., and the drill press is driven by 1 H.P. CD motor 1200 R.P.M. The banding machine is driven by 3 H.P. CD motor, 1200 R.P.M., and the grindstone by 1 H.P. motor 1200 R.P.M. The baking ovens are heated by Cutler-Hammer space heaters. The Chief Electrician's office is located between the Electric Shop and Storeroom, and is not shown on building plan.

DEPARTMENTAL ORGANIZATION

The majority of stationary motors A.C. and D.C. are so arranged that standardization of parts has been accomplished to a very large extent. However, no attempt has been made in this paper to show all the motors in the plant. Incidentally, there are 800 motors of various sizes in service. The controller in use on D.C. motors generally, except cranes and tables is of Westinghouse manufacture. There are some General Electric and Cutler-Hammer on certain applications. All A.C. motors up to 7½ H.P. are controlled by either Westinghouse 815 switches with K.N. Relays or General Electric CR 9006 switches with temperature O.L. relays. All A.C. motors above 7½ H.P. are provided with Westinghouse type A and A.F. starters and some with General Electric CR-1034 hand starters and Cutler Hammer bulletin 9601 automatic starters. However, the installation of hand starters has been discontinued in preference to automatic type with push button control. A large number of Westinghouse CS and SK motors are equipped with sealed sleeve bearings and are giving splendid results. There are only a few installations of anti friction bearings. However we expect to install roller bearings on MC motors just as soon as possible.

Our plant is devoted to the manufacture of high-grade automobile sheets from the raw material to the finished product. All our equipment is completely electrified and we manufacture all our own power, having a consumption of about 3½ million kilowatt-hours per month. We have about 800 motors with a connected capacity of about 18000 HP. and station capacity of 7,500 KW. Our Electric Department employs 94 men, and is divided into the following divisions: Inspection, Repair Shop, Construction, Sub-Stations, Meters, Crane Operators, Coal Mine, Electricians.

For taking care of inspection, we have the plant equipment divided into three sections with an inspector and two helpers in each of two sections on eight-hour shifts, seven days a week. The remaining section has one inspector ten hours day turn, seven days per week.

Each inspector makes out a report, as shown in an accompanying illustration, at the end of each turn which is sent to the Chief Electrician's office. The inspectors are responsible for the condition of all electrical equipment in their section with respect to the motors up to and including motor pinion and all electrical and mechanical work on traveling cranes. Each inspector has a third portion of the equipment in each of the first two sections which he is responsible for from a maintenance standpoint, but he is always available in the entire section in case of a breakdown, etc. These same inspectors also make the cranemen responsible for a certain part of the traveling cranes with respect to cleaning and lubricating them.

The Inspection Division is not expected to do any repair work on spare parts, except of a minor character and complete spare parts of both mechanical and electrical equipments are located at central points. The inspector's report form shows what has been used each day and provisions are made immediately to replace the part, either by purchase or by

other crews as explained later. This system is, we believe, very successful.

Our Electric Repair Shop is located in a central portion of the plant and is equipped to handle all electrical and mechanical maintenance in the Electrical Department. We have a shop foreman, armature winder, machinist and repair electrician employes here, also we have floor space for two electric millwrights who work there at times in carrying on millwright work in the department in connection with bearing, re-babbitting and machining fits, and the like.

The millwright, inspection and repair shop forces are very closely in touch with each other at all times with respect to the condition and location of required spare parts.

We maintain a Construction Division for the purpose of installing all new work and making changes or improvements when desirable.

We employ a meter man to properly maintain our meters and make power charges for each month. This man also maintains a close check on pyrometer equipment at the annealing furnaces and also checks overload relay settings on the important units. He also takes care of any drafting that may be required. This man also keeps a check of insulation resistance of the more important units, cables, etc.

We have about 56 cranemen who are hired and trained by the Electrical Department. All cranemen are subject to the orders of the Electrical Department with respect to the proper handling of crane equipment and ability to meet the requirements of the various department superintendents. This system is very successful.

Complete data is filed on all electric and mechanical equipment in the Chief Electrician's office which are cross indexed by a clerk. This clerk also balances his day's disbursements against his storeroom inventory daily, on both electrical and mechanical spare parts, so that the possibility of overlooking parts used is very remote.

We have our own coal mine with a mine electrician in charge. We have a motor generator set located in the center of the coal field with a bore hole for direct current cables leading to the mine to run mining machines and locomotives. The maintenance of all equipment in the mine is done at the mill repair shop.

We believe that standardization has saved us more than any other one thing. We have found it possible to limit the sizes of track wheels for the various bridge and trolley wheels on 26 traveling cranes. It should be remembered that no effort was made originally to standardize rail sizes or wheel diameters, it being accomplished by consideration of various axle diameters and hub lengths. Very close checks are maintained on motor and control parts, so as to keep down the variety of parts required.

We have also accomplished considerable saving through the standardization of gears, brake wheels, shoes, bushings, etc.

We have had trouble with some of our flexible couplings due to severe service in some cases and lack of proper attention in others. We have corrected this by installing improved types of couplings in some instances and devoting more attention to inspection and maintenance of the couplings in others. We have also had considerable trouble with mechanical parts on forging manipulator cranes which are used in forging ingots under a steam press. These troubles are being overcome by changes of design and using better material in parts showing the greatest abuse.

The most outstanding saving made in the past two years has been brought about by the adoption of sealed sleeve type bearings on our general purpose motors. This type of bearing has reduced our rewinding cost by 40 per cent. There are several other changes that have helped to lower costs, such as a more liberal use of automatic control at our coal mine, sub-station, and our hot and cold roll drives, thereby eliminated considerable attendance and saving operators' wages.

For testing we use a Graphic Wattmeter, Weston indicating voltmeter and ammeter, Weston shunts 25 to 800 amps. Esterline shunts 25 to 400 amp. Westinghouse A.C. voltmeter and ammeter, Esterline "Utility" current transformers 25 to 800 amps., Weston millivoltmeter 0 to 300 volts, Brown Instrument Company Heatmeter, 0 to 2000 deg., Biddle Bridge Megger, Jagabi speed indicator, stop watch, potential transformers 20/1 and 2/1, potentiometer 75 to 2000 deg., Westinghouse portable standard wattmeter. We find the graphic wattmeter, Biddle Megger and Heatmeter are of most value in performing the work outlined by the meter division.

In our electric repair shop we use 30" American lathe, shaper, drill press, large wheel press, armature banding machine, varnish dipping vats and baking oven. We believe that from a mechanical standpoint the shaper, lathe and wheel press permit the greater savings. From the electrical standpoint, the baking equipment permits greater savings on winding costs. However, we consider all of the equipment indispensible to us because of the large amount of mechanical work which we have to maintain. It may be of interest to note that we purchase rough castings where possible, and do our own machine work.

COAL MINE

The company owns and operates their own coal mine near the plant with the following equipment:

Mine Substation. A 2300 V. transmission line outlined under Power House is extended to the working regions where a substation is built near the center of the coal field. This substation contains Ridgway motor generator set, 200 KW 275 V. 1200 R.P.M. generator direct connected to 300 H.P. synchronous motor, 2300 V., 80% leading power factor, with the following control equipment:

Motor panel consists of A.C. ammeter, D.C. field ammeter.
Field rheostat.
Potential and current transformers.
1 A.C. voltmeter.

Mounted apart from this panel is a 4 pole double throw, hand operated oil switch with under-voltage and overload relays and inverse time element attachments. A generator panel contains the following:

1 D.C. voltmeter.
1 1200 amp. ammeter.
1 800 amp. 2 pole knife switch.
1 Rheostat mounting.
1 General Electric automatic reclosing circuit breaker.

Fig. 38 shows interior view of this sub-station.

The direct current cables are run down through an air shaft to the mine working regions. The sub-station building proper contains a fan house and is heated with Cutler Hammer space heaters and provided with a small air compressor for cleaning the set. The fan is belted to 5 H.P. SK motor 1800 R.P.M. so arranged that circuit breaker interruptions do not shut it down unless the set comes to rest. No attendant is required at this substation other than the mine electrician.

A General Electric 4 ton combination reel and trolley locomotive and a Goodman 4 ton locomotive are used for gathering coal from working places. A Goodman 8 ton locomotive is used for hauling coal trains to the tipple, a locomotive shop with the usual

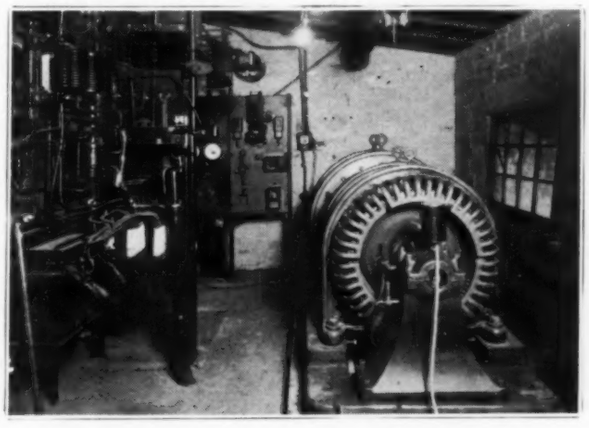


FIG. 38—Mine Substation Equipment.

locomotive pit and blacksmith shop is located at the tipple with motor driven blower. Two 35-B short wall Jeffrey mining machines are used for cutting coal and the following pump units are used in the mine for pumping water:

1 15 H.P. Allis Chalmers Manufacturing Company centrifugal pump unit, 300 G.P.M. direct connected to Allis Chalmers DC motor 1800 R.P.M. with Cutler Hammer rheostat.
1 10 H.P. Allis Chalmers Manufacturing pumping unit with Allis Chalmers 10 H.P. motor, 1200 R.P.M. with Cutler Hammer rheostat.
2 Dravo Doyle plunger type pumps, 150 G.P.M. direct connected to SK motor 1800 R.P.M. with type D rheostat.

Cutler Hammer space heaters are used in heating the various shops at the mine and also in sand dryer for locomotives.

All transmission lines are hard drawn figure eight trolley wire for locomotives and 4/0 hard drawn round wire for mining machine feeders. All line materials are of Ohio Brass manufacture. Provisions are made for furnishing direct current from the mill for pumping and fan motors in case of failure of the Ridgway MG set.

TWENTY FOOT MILL WELL

Pure drinking water and water for certain manufacturing purposes is obtained from a 20 ft. well which contains an Allis-Chalmers 3000 G.P.M. centrifugal pumping unit direct connected to 125 H.P. 2200 V. induction motor and Westinghouse hand starter. This unit is an exact duplicate of the units at the River Pump House. Three storage tanks of 100,000 G.P.M. capacity receive water from this pump for stand-by service and are so elevated that sufficient pressure exists at all points in the mill. The Company also owns 96 modern residences for mill employees and a storage tank is located near them for water supply which is piped in the usual manner from the tank. This storage tank receives the water from the stand-by tanks by means of a centrifugal pumping unit located near the well and is 300 gallons capacity direct connected to 15 H.P. induction motor 1800 R.P.M. with Cutler Hammer #9601 starter and pressure gauge. The step-down transformers for this unit are three 7½ K.V.A. Packards located in the mill well building. The lights for the residences as well as several other cottages and main office are furnished by General Electric transformers located on suitable pole platforms and connected to the mine and well 2300 V. feeders and stepped down to 110 volts.

SAFETY

The question of Safety to employees has been made a paramount issue by the officials of our Company and great care has been exercised during the construction of the plant and since that time to safeguard as far as possible against accident of any kind. We also maintain a first class hospital with trained nurses on 24 hour duty with a surgeon in daily attendance. Our Safety organization was outlined by the writer at our Philadelphia Convention and may be had from the files of "Iron & Steel Engineer."

All equipment with the exception of building steel was installed by the Company. Joseph Breslove, Consulting Engineer, Pittsburgh, was retained as Consulting engineer on electrical equipment, Power Plant and allied subjects. Engineering Design and Construction was carried out under the supervision of C. W. Kinter, chief engineer, Follansbee Bros. Company. Mr. Gilbert Follansbee is General Manager of the Toronto Plant.

SPECIAL FEATURES OF TORONTO PLANT, FOLLANSBEE BROS. COMPANY, TORONTO, OHIO

By JOSEPH BRESLOVE, C.E.*

The Toronto plant of the Follansbee Bros. Co. presents a number of features of unusual interest and a brief resume of these may be timely. It supplements the Company's older operation at Follansbee, W. Va., where it commenced the manufacture of sheet and tin plate in 1904. Considerable pioneering was done at the Follansbee plant under the direction of Mr. Wm. Banfield, Vice President and General Manager at that time. One of the developments being a high grade, open hearth hammered sheet suitable for deep drawn work. The annual capacity of the Follansbee mill is 60,000 tons.

The new mill's claim to distinction lies in a number of radical departures from the accepted practice of the period. Any single one of these elements would probably not be considered extraordinary, but

*Consulting Engineer, Pittsburgh, Pa.

(Concluded on page 203)

The Application of Direct Current Motors to Main Roll Drives*

By HARRY A. WINNE†

AT the present time, of all the motors installed on steel mill main roll drives, only about 25% are direct-current machines, the remainder being almost entirely induction motors. The wide use of the induction motor for this service is explained by its reliability of operation, ability to use a-c. power without conversion, high efficiency, freedom from commutation troubles and low first cost and maintenance. With the addition of Kraemer or Scherbius regulating equipment, adjustable speed control of an induction motor can readily be obtained, as evidenced by the fact that in this country alone, some fifty Kraemer and over seventy Scherbius equipments are in successful operation.

Nevertheless, in the year 1926 the number of direct current motors purchased for main roll service exceeded the number of a-c. motors in the ratio of about two to one. Why? Largely because of the development and increasing use of the modern high-speed continuous bar and strip mill with individually driven closely spaced stands. The effect of this type of mill on the use of d-c. motors is what we might term cumulative. In the first place, the d-c. motor seems to be, as a rule, the most suitable drive, of which more later, and in the second place, a single mill may be driven by from four to a dozen or more motors, as compared to the older installations with one or two motors on a mill.

It is not within our province to trace in detail the reasons for and the progress of the development of this type of mill. Due to its great flexibility and the

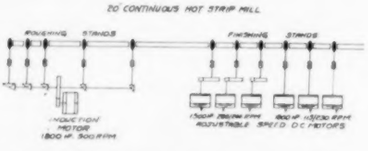


FIG. 1—Layout of continuous hot strip mill. Edging stands not shown.

wide range of products obtainable from a single mill, the reduction in number of roll changes, the increase in production and the reduction of operating costs which it brings about, it is apparently here to stay. Recent developments indicate that the continuous mill is to be used for rolling sheet, at least in the heavier gauges, so that unquestionably many more such mills will be installed.

The general layout of a typical continuous strip mill, not including the edging stands, is shown diagrammatically in Fig. 1. The first four stands are driven by a single constant speed induction motor. A mill of this type uses slabs of the same thickness for a wide range of finished strip, so that the roughing passes remain about the same; furthermore, in these first passes the slab may not be long enough to reach from one stand to the next. Therefore, adjustment of the relative speeds of the roughing stands is not required.

In the intermediate and finishing stands, however, the conditions are different. In order that the strip may be finished reasonably hot, and that the mill may not become too long, the finishing stands are spaced closely. In one mill the distance between stand centers is less than eight feet, but 15 to 20 feet is a more usual spacing. Consequently, a single piece of strip will extend through several stands at once. Now it is evident that if strip of different thicknesses is to be made from slabs of a single thickness, the relative speeds of the various finishing stands must be adjusted every time the mill set-up is changed, in order to prevent excessive looping or stretching of the metal between stands. This then necessitates adjustable speed drives for these stands.

Furthermore, it must be possible to obtain very fine and close adjustment of the speed, for the strip entering the last stand may be two hundred or more feet long, traveling 1000 to 1500 feet per minute, and unless the relative speeds of the various stands are closely adjusted, the loop may get out of control or the metal may be stretched and broken.

The fact that very accurate and flexible speed control must be obtained, and that there are a number of these drives on a single mill, usually results in the selection of direct current motors for the finishing stands of such a mill. While a single induction motor with speed regulating equipment is usually less expensive than the corresponding direct current motor and motor generator set, when we come to compare the cost of four or five induction motors, each with its own individual regulating equiment, with that of four or five corresponding d-c. motors and only one or two motor generator sets to supply power to all of them, the cost difference will usually favor the d-c. apparatus. Of course, the induction motors would have somewhat higher efficiency, but this is sacrificed for the ease, accuracy, and flexibility of speed control of the d-c. motors on a drive of this character.

Therefore, we find that d-c. machines are almost invariably used for individually driving the finishing stands of a continuous mill. We also find them used justifiably where adjustable speed is required on a drive of small capacity, say, 500 h.p. or less, because in such small units adjustable speed induction motors are more expensive. Or we may find a plant in which two or three adjustable speed mills are grouped together, driven by moderate capacity d-c. motors supplied with power from a single motor generator. No hard and fast rule can be given as to when to employ d-c motors and when a-c. Each individual case must be carefully studied before an intelligent decision can be reached. Too often in the past unfounded prejudices have been allowed to

*Presented at meeting of Birmingham Section, January 29, 1927.

†Industrial Engrg. Department, General Electric Co., Schenectady, N. Y.

overbalance sound engineering judgment and many d-c. motors have been installed when adjustable speed a-c. drives should have been used.

Now, assuming that we have decided that a certain mill is to have d-c. drive, let us discuss some of the factors affecting the selection and application of the motors to the drive, all of which must be very carefully considered before specifications and requests for quotations can be issued to the electrical manufacturers.

Geared vs. Direct Connected Drives.

Take first the mechanical end: Shall the drive be geared or direct connected? Gearing may have two advantages: it may reduce the overall cost and it may permit using duplicate motors on the various stands. As for the cost, a high speed motor is, within limits, less expensive than a slow speed machine. However, unless the high speed unit runs two to three times the mill speed, its cost added to that of the gear will be more than that of the direct connected motor. In other words, unless the gear ratio can be made at least 2:1, the gear had probably better be omitted. The gear ratio will be determined by the mill speed and the maximum desirable motor speed, and this latter in turn is fixed largely by the capacity of the drive. It is rarely desirable to have the product of the motor rating in horsepower multiplied by its maximum speed, greatly exceed a value of 1,000,000, for a single armature. For example, if the motor rating is 2500 HP nothing can be gained by making its maximum speed much above 400 RPM, and the problems of design become difficult.

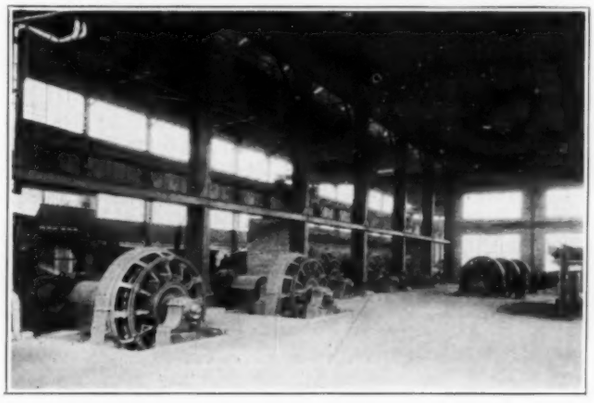


FIG. 2—1500 h.p. and 1800 h.p. d-c. motors driving a 20″ hot strip mill.

If two or more stands of a mill require approximately the same power, and the drives are geared, using different gear ratios for the several stands will permit making the motors exact duplicates. This is obviously desirable, but not worth spending a lot of money for, as the cost of necessary spare parts is not great.

If the motor is to be direct connected to the mill, the coupling-end pedestal should be equipped with a suitable thrust collar in order to resist the end thrust that may be occasioned in case the spindle between motor and mill breaks. If the motor drives the mill through gearing, this thrust bearing is provided on the gear shaft and, therefore, is not required on the motor.

Flywheels

A direct-current drive is very rarely equipped with a flywheel because on the types of mills to which such motors are applicable the passes are so long that a flywheel would be of no use. If some unusual conditions make it desirable to put a d-c. motor on a roughing mill on which the peak loads are short, on the order of not more than 3 or 4 seconds, a flywheel may be used to reduce the loads on the motor and in this case the motor should be provided with a small amount of cumulative compound winding so that it will slow down as the load comes on and permit the flywheel to give up some of its stored energy.

Ventilation

Motors may be built arranged for either forced or self ventilation. In a location as dusty and dirty as the ordinary steel mill, money spent in providing an enclosure and an adequate supply of clean air for the motor will pay good dividends in the form of decreased maintenance costs. If the motor is to be located out in the mill, it should be of the enclosed ventilated type. If in a separate motor room, it may be either force-ventilated or open, but in any case clean air should be supplied.

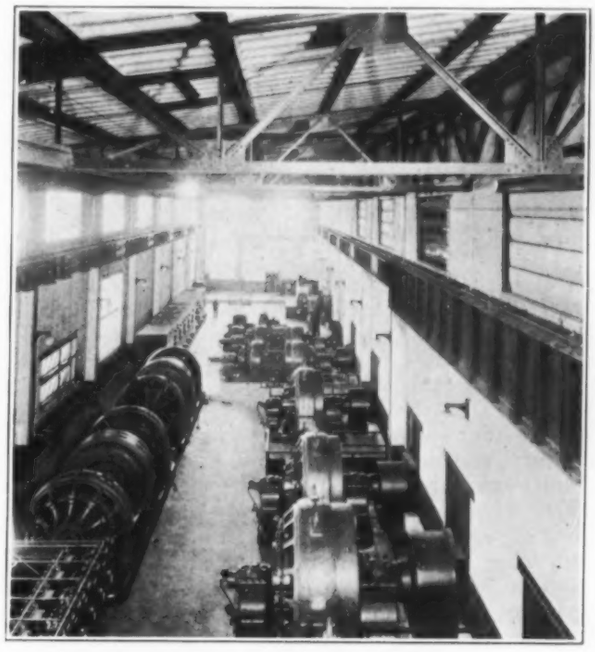


FIG. 3—Motor room of high speed continuous merchant mill.

Means must be provided for the warm air to leave the room, but the exits should be small enough to cause the air in the room to be under a pressure very slightly above the surrounding atmosphere. This will effectively prevent the entrance of dirt and dust through cracks or other small openings.

In practically all cases where air is forced into the motors or motor room, some form of air cleaning equipment should be installed. Both wet washers and dry filters of the grease-film type are successfully used.

The amount of air which must be provided is at least 100 cubic feet per minute for each kilowatt of

loss in the machine when operating at its maximum sustained overload.

Operating Voltage

Having considered the various mechanical features which must be taken into account in applying a direct current motor to main roll drive, we will now pass on to the electrical characteristics, starting first with the question of that operating voltage the motor should be designed for.

D-c. main roll motors usually are built to operate at either 600 or 250 volts. If it is possible to choose between the two, 600 volts is preferable for large motors of, say, 500 h.p. and above, from the standpoint of cost of motor, switchboard, feeder copper, etc. Small motors, particularly if slow speed, are less expensive if designed for 250 volt service.

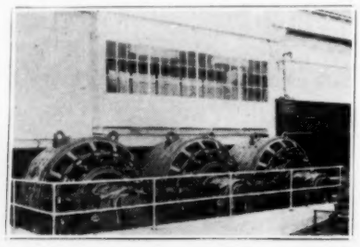


FIG. 4—Three closely spaced 2000 h.p. d-c. motors driving individual stands of a continuous mill.

Most modern mills requiring d-c. motor drive will have several motors on the one mill, and in such cases it is advisable to install one or more motor generators which will supply power to these main roll motors only. The argument is sometimes advanced that the main motors should be made 250 volts so that they and their motor-generators can be tied in with the 250 volt shop circuit. However, this circuit usually has rather poor voltage regulation, which is not conducive to good speed regulation on the mill, and is subject to interruptions which might shut down the whole mill. Consequently, it is much better to keep the main drive power supply entirely separate from the auxiliary circuit, and therefore the main drive may be made 600 volts, if this is desirable, as it usually is.

Field Excitation—Self or Separate

Motors should preferably be excited from the same source as are the generators which supply power to them. This means that if the generators are self-excited the motor fields should be connected to the same bus as the armature circuit. This condition usually exists when one generator or group of generators supplies power to a number of different mills.

In most cases where there are a number of motors on one mill, as on the continuous strip mills, one or more motor generators supply power to the single mill only. In such a case the motor generators may be considered a part of the mill drive, and it is best to excite both motors and generators from a separate 250 volt source. This source may be either a motor driven exciter set, or an exciter direct connected to the motor generator.

Separate excitation for both generators and motors is absolutely necessary if Ward Leonard control of speed or of motor starting is to be used. It is desirable also because the fields may be wound for 250 volts at less cost than for 600 volts; the arcing at the field switches is less vicious; 250 volt contactor coils and other control are more reliable than 600 volt devices, and the excitation bus may be used as a control source; 250 volts or less is necessary for excitation of tachometer generators if such are used for speed indication.

It is not considered necessary to install a spare exciter set, for all steel mills have 250 volt d-c. power available which in emergency could be used for excitation. However, this should be considered as an emergency source only, as its voltage is rather variable and it is subject to interruptions.

Methods of Speed Adjustment—Field or Armature Voltage Control

The speed of a d-c. motor may be adjusted either by varying the field strength, the armature voltage, or both, the former being the most common method. If several motors operate from a common bus, and their relative speeds must be adjustable, then field control must be used. On the other hand, if the speeds of all the motors are to be adjusted as a unit, this can be done by varying the generator voltage. If a single motor operates from an individual generator, it can be controlled by either or both means.

There are limitations to the range in speed that it is practicable to obtain by field control, the principal factors being commutation and stability. For mill motors it is desirable not to exceed a 2:1 range, although many motors have been built for 2.5:1 and a few at 3:1. As the range increases it becomes

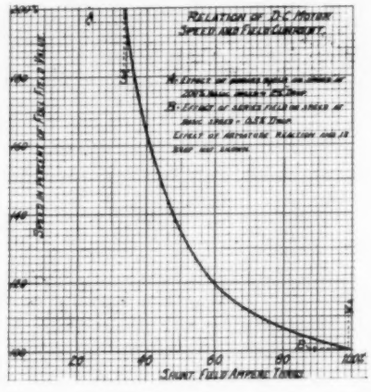


FIG. 5—Relation of d-c. motor speed and field current.

more and more difficult to obtain successful commutation on overloads at the top speed, without unduly raising the cost of the motor.

It is obvious that as the field strength is decreased, the torque per unit of armature current will decrease. However, at the same time the speed increases so that the product of torque and speed, or the horsepower output, remains approximately constant. In other words, a motor designed for speed adjustment by field control is inherently a constant horsepower unit. Actually, owing to the better ventilation at the higher speed, it may be possible to give the motor a slightly higher continuous rating at the top than at the base or full field speed, if this is necessary. However, as commutation difficulties

increase with the speed, the maximum momentary load that the motor can carry is no greater, and may be less, at the maximum speed. For example, we may have a motor rated 1000 h.p.-350/700 r.p.m, capable of carrying momentarily 200% load at any speed within its range. From the standpoint of heating, we may be able to rate this motor 1150 h.p. at 700 r.p.m. but its maximum peak capacity still remains at 2000 h.p. and does not increase to 200% of 1150, or 2300 h.p. at 700 r.p.m. As a matter of fact, a motor will commutate successfully a higher momentary peak load at base speed than at maximum, particularly if the range is great.

Now, if we obtain speed control by varying the armature voltage, keeping the field constant, the torque per armature ampere remains fixed, and so we get constant torque operation throughout the range of armature speed control.

The continuous strip and bar mills usually require motors rated on a constant horsepower basis throughout the normal operating range, since light material with correspondingly light drafts is rolled at the higher speeds while heavy material with correspondingly heavier drafts and torque requirements is rolled at the lower speeds.

By varying the generator voltage from zero to its normal value, a correspondingly wide range in motor speed can be secured. However, unless the motor is force-ventilated, it cannot be operated continuously at very low speed as the natural ventilation will not be sufficient to cool the armature and field. Furthermore, at low voltage the speed regulation ,of the motor and voltage regulation of the generator will be poor, as the voltage drop due to the resistance of the armature circuit remains constant for a given current, and thus is a greater percentage of the applied voltage at low voltages than at high.

Unless suitable provision is made in the control, unsatisfactory operation may result if a compound wound generator is used in connection with armature voltage speed control. Suppose the generator is designed for flat compounding at normal voltage. Operating under this condition, the series field ampere-turns at normal load will be a certain percentage of the shunt ampere-turns. Now at half-voltage the actual value of the series turns is the same for the same armature current, while the shunt turns will be reduced at least one-half, and probably more because of the shape of the saturation curve. (See Fig. 5.) Therefore the percentage of series turns is more than doubled and the machine will be heavily overcompounded. At very low voltage it will be practically a series generator. Therefore, it may be necessary to shunt or short the series field at low voltage.

As a general rule, except on reversing drives, the normal operating speed range is obtained by motor field adjustment. Armature voltage (Ward Leonard) control may be used for starting the mill, as explained later, or for obtaining a low speed while running a trial bar through the mill.

Speed Regulation—
Shunt and Compound Motors

Most main roll motors are shunt wound, as fairly good speed regulation is desired; paradoxical as it may seem, in some cases when very good regulation is desired, a small amount of series field winding is added. The reason is as follows: Suppose we adjust the brush position on a motor to give a flat speed curve, that is, the same speed at full load as at no load, with full field. If we now weaken the shunt field, to operate at a higher speed, the speed curve will change from flat to rising, as the effect of the armature reaction will be greater under the weakened field condition. For example, if we have a shunt wound motor with a full field speed of 200 r.p.m., we can set the brushes so that both the no load and full load speeds will be 200 r.p.m. With the same brush position and the field weakened to give a no load speed of 400 r.p.m., the full load speed may rise to, say, 412 r.p.m.

By applying a small amount of cumulative series field, the full load speed under weakened field condition can be brought down to or below the no load speed. With full shunt field, i. e., at base speed, the effect of the series field will be greately reduced, as it will constitute a much smaller percentage of the total field ampere-turns than it does at top speed. Therefore, the reduction of the basic full load speed will not be so great as that of the top full load speed and the overall speed regulation of the motor will be bettered. This variable effect of the series field at different speeds is shown in Fig. 5.

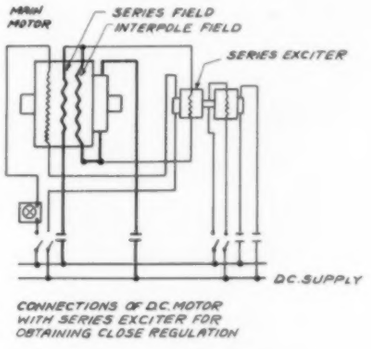


FIG. 6—Connections of d-c. motor with series exciter for obtaining close speed regulation.

A device sometimes used to obtain close regulation is a "series exciter." Referring to Fig. 6, a small d-c. machine, driven at approximately constant speed by a separate d-c. or a-c. motor, has its armature connected in series with the shunt field winding of the main motor. The field of this exciter is energized by the voltage drop across the interpole field of the motor, so that its field and consequently, its armature voltage is proportional to the load on the main motor. The exciter is so connected that its voltage opposes the main excitation voltage on the motor field, that is, it is differentially connected. The motor also has a straight series field connected accumulatively.

To illustrate the action of the series exciter, let us examine a concrete example. First consider a straight shunt wound motor with no series field nor series exciter. Assume that with 100% shunt field current, or ampere turns, the no load speed is 100%. Under this condition the resistance of the field circuit we will call 100%, and the voltage applied to the field circuit 100%. Now suppose with this same field full load is applied to the motor and its speed drops to 96%, and to bring the full load speed up to 100% we have to decrease the shunt field to 90%.

If we now take the load off the motor and adjust the field rheostat so that we get a no load speed of 200% we may have for this condition a field of 33.3%, which means that the resistance of the field circuit has been increased by means of the rheostat to 300%. If we now apply full load the speed may drop to 198%, and to bring it back to 200%, say we have to decrease the field ampere turns to 33.0%.

That is, for the straight shunt motor, we will have operating conditions as summarized in the following table:

ASSUMED OPERATING CHARACTERISTICS OF SHUNT WOUND MOTORS

	Basic Speed	Top Speed
No load speed	100%	200%
Full load speed	96%	198%
Excitation circuit voltage	100%	100%
Field circuit resistance	100%	300%
Shunt field ampere turns	100%	33.3%
Field ampere turns necessary at full load for zero regulation	90%	33.0%

Now let us add a cumulative series field, and the series exciter differentially connected as shown in Fig. 6. By a few simple calculations we determine that to give the desired zero speed regulation at both top and bottom speeds we need a series field which

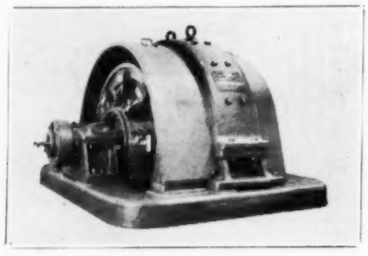


FIG. 7—Enclosed ventilated mill type main roll motor.

with full load current flowing is equivalent to 4.5% of full shunt field, and the exciter adjusted so that its armature voltage, with full load on the main motor, is 14.5% of the excitation circuit voltage.

Now the conditions will be as follows:

OPERATING CONDITIONS AT FULL LOAD, WITH SERIES EXCITER AND SERIES FIELD

	Basic Speed	Top Speed
A—No load speed setting	100%	200%
B—Field circuit resistance	100%	300%
C—Differential field circuit voltage due to series exciter	14.5%	14.5%
D—Voltage applied to field circuit = 100%-14.5%	85.5%	85.5%
E—Shunt field ampere turns = $\frac{D}{B}$	85.5%	28.5%
F—Ampere turns due to cumulative series field	4.5%	4.5%
G—Total ampere turns = E plus F	90.0%	33.0%

That is when running at basic speed, with a no load field of 100%, we will have at full load, with no change in the rheostat, only 90% field, which is the value required for 100% speed. Similarly, at top speed with a no load field of 33.3%, the field resulting at full load will be 33.0%. In other words we will have zero regulation at both top and bottom speeds. At intermediate values the regulation will not be quite so good as this.

Special speed regulating devices, working on the shunt field, designed to hold the speed within a fraction of a per cent, can be and have been furnished, but in most cases the additional complication and expense are unwarranted. Such an equipment was furnished with the Trumbull Steel Company's 14-inch hot strip mill drive, and while it worked very satisfactorily, it was soon found that entirely successful operation could be obtained without the regulating devices and they are not now used. On most of the recent installations, no regulating devices are used or needed.

This question of speed regulation on continuous mill drives has attained a much exaggerated importance. As a matter of fact, such mills can be and are successfully operated with drives having very poor regulation, but it is essential that the control provide a larger number of operating speed points so that the full load speed can be carefully and quickly adjusted. On any continuous mill it is impossible to pre-determine exactly what the speed of each stand should be to maintain just the right amount of looping between stands. Therefore, after a change in mill set-up, the roller always has to make some adjustment in the speed of the motors, regardless of how close regulation they may have. He makes this adjustment while the metal is in the stands; in other words, he sets the full load speeds at the proper values by trial. Now when the metal leaves a stand it makes no difference whether the speed of that stand rises ½% or 10%, for as soon as the next piece of metal hits these rolls, the speed will immediately drop back to the correct value. In fact, it will instantly drop to a point somewhat below this value, and then return to it, owing to the time required for the slight flux change in the motor. This quick drop and return is a valuable characteristic, immediately throwing a small loop in the metal and preventing the possibility of stretching it.

As will be explained later under the subject of "Control," the speed control of the finishing mill motors is always compactly grouped in the operating pulpit so that a single operator can readily take care of five or six stands, quickly making any necessary adjustments in speed as the metal is going through the mill.

The maximum speed regulation for 100% load change can usually be kept down to 3% or 4% on a 2:1 speed range motor without the use of any auxiliary regulating devices. Motors with this much or more regulation are giving perfect satisfaction on different types of continuous mills operating at speeds up to and above 2000 feet per minute. This experience has shown that the addition of auxiliary speed regulating equipment, with its attendant complications of control and apparatus, is rarely if ever, justified.

I am convinced that even if the drives on a continuous mill have absolutely zero regulation, it would still be necessary for the operator to be constantly "on his toes" and to make slight adjustments in the relative speeds to take care of varying conditions such as temperature of slab, quality of steel, etc. A very good demonstration of this fact was obtained on the Trumbull Steel Company's 14-inch strip mill. As previously mentioned, the motors are equipped with regulating devices which hold the speed at any desired value with an accuracy of less than 1/20 of one per cent, and yet the operator has to do just as

much "juggling" of the speed settings when the regulators are in operation as when they are not. In this same plant is a continuous mill in which adjacent stands, spaced 20 feet, are driven by different induction motors, with Scherbius regulating equipment, on which the speed regulation happens to be from 6% to 8%; yet no trouble is experienced in rolling strip up to 22 inches wide at 900 feet to 1000 feet per minute. You can draw your own conclusions from these two examples.

"Mill Type" Motor Construction

A d-c. motor for main roll drive should ordinarily be of considerably heavier construction mechanically than the usual general purpose type of motor. Most electrical manufacturers furnish for this purpose motors of what has come to be known as "Mill Type" construction. Salient differences between the usual mill type and standard industrial type motors are as follows: The armature spider is of steel instead of cast iron and is of especially heavy and rugged construction. The bearings are supported in what are known as mill type pedestals, which bring the center line of the shaft down as near the base as possible, and are designed with special regard to withstanding heavy side and end thrusts. If the motor has a thrust collar, the coupling end pedestal is steel rather than iron and is cross keyed as well as bolted to the base in order to successfully resist the thrust to which it may be subjected. The motor bearings are split and provided with ball seats. The motor shaft is made of large diameter so that the normal load stresses are low.

Accessories

It is advisable to have each adjustable speed drive equipped with a speed indicating device, having the indicator conveniently mounted in the operating pulpit. For this purpose a small separately excited d-c. generator may be geared to each motor. The armature of each of these machines will be connected to a voltmeter, mounted in the pulpit, calibrated to indicate speed. The tachometer generators are operated with their fields highly saturated and all the fields of the machines on a mill may be connected in series so that even if the field current does change slightly, it will affect all indications alike, so that the ratio between indicated speeds will be correct even though the actual speeds may be somewhat different from the indications. The ratio is, of course, much more important than the actual speed as it is the ratio which determines the amount of looping between stands.

Among the accessories which are often applied to d-c. drives may be mentioned bearing temperature relays and electric heaters. Bearing temperature relays provide a very desirable protection and will give indication of trouble, usually in time to save a bearing, and always soon enough to save the shaft and armature from harm. These relays are sometimes connected so as to automatically shut down the drive, but a more desirable arrangement is to have them wired to an annunciator with suitable alarm, as this will permit clearing the mill of metal before shutting down.

If the motor room is not heated, when the motors are not in operation they are apt to sweat when the room temperature rises quickly. To prevent this, an electric heater may be mounted in the pit beneath the motor with its controlling contactor interlocked with the motor control so that it operates only when the motor is shut down. To make the heater really effective, the motor must be provided with a cover of canvas or similar material when it is not running.

Control and Switchboard

Passing on to the consideration of what control and switchboard equipment should be installed, we must first decide whether we are to use magnetic or Ward Leonard starting. The Ward Leonard system of starting is applicable only when one or more generators supply power to only the motors on a single mill. It is obvious that all the motors must be started at the same time although any one can be stopped by opening its particular circuit breakers. Of course, all starting resistance and contactors are eliminated.

Magnetic control is considerably more flexible, as individual motors can be started and stopped at will, and other equipment can be operated from the same bus if desirable. However, for large motors the starting resistor and control panel are expensive, and if conditions permit its use, Ward Leonard starting may effect a desirable economy.

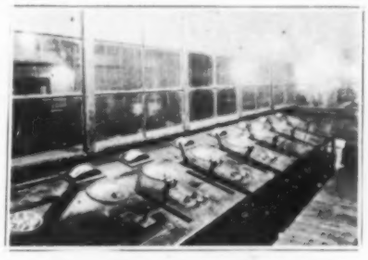


FIG. 8—Pupit control desk for continuous mill, showing master switch handles, levers for field rheostats, tachometers, and ammeters.

Magnetic Control Equipment

The usual magnetic control equipment for a d-c. mill motor consists of a control panel, a starting resistor, a master switch, a field rheostat, and one or more stop push buttons.

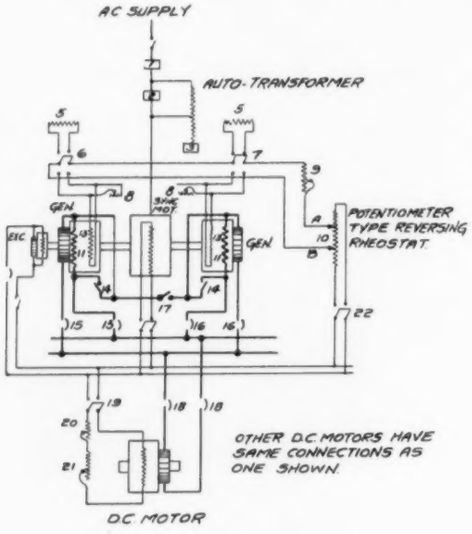
The control panel is equipped with the necessary accelerating contactors and relays, and for motors of moderate capacity, may also contain line switches and overload relays. For larger motors it is better practice to put the line switch and overload protection in the form of circuit breakers on a separate switchboard panel.

Usually some provision for reversing the motor in case of emergency is desirable but this is readily taken care of by a reversing field switch, rather than by reversing contactors in the armature circuit, as the latter, especially for large motors, are expensive. Reversal is so infrequent that a hand operated double throw field switch on the switchboard or control panel is satisfactory.

The field rheostat may be either motor or hand operated. When very close speed adjustment is necessary, as on a continuous mill having individually driven stands, it is good practice to include both a motor and a hand operated rheostat connected in series. The hand rheostat should have only 10% to

20% of the amount of resistance in the motor operated rheostat, so that it can be used for very fine and quick adjustment of the speed. It is preferably made of the lever operated type and mounted in the mill pulpit. The hand rheostat acts as a vernier for the main rheostat, permitting very close speed adjustment. It also allows the operator to very quickly make the small adjustments in speed that are required to keep the looping of the metal in the mill within the desired limits.

The importance of the hand operated vernier rheostat on continuous mill drives cannot be overestimated. The operator very soon learns just how



ELEMENTARY DIAGRAM-M-G SET AND MILL MOTOR WARD LEONARD STARTING.

FIG. 9—Elementary diagram of connections of dc-. motors and generators arranged for Ward Leonard starting.

much of a movement of the rheostat handle is necessary to give the desired change in the loop and he can see and feel just how far he is moving it—something that is absolutely impossible with the electrically operated rheostat.

Switchboard for Motors Having Magnetic Starting Equipment

If the motor rating is of the order of 500 h.p. or more, it is good practice to install a separate switchboard or feeder panel for each motor, in addition to the magnetic control. On this is usually mounted a line circuit breaker providing overload protection, a line lever switch, the motor field switch, and a line ammeter.

On continuous mill drives it is very desirable to place in the operator's pulpit a steel desk board on which is concentrated in as small a space as possible the master control and indicating instruments for the motors. This desk will comprise a section for each motor on which will be mounted the following: control switch or master switch for starting and stopping the motor; control switch for motor operated field rheostat; lever for hand operated rheostat; tachometer; line ammeter.

The pulpit in which the master control desk is placed should be located at one side of the mill, about midway of the finishing stands, and at a sufficient height above the mill floor so that the operator in it can command a good view of the whole mill, but more particularly of the finishing stands.

Switchboard Equipment for Ward Leonard Starting

To utilize the Ward Leonard system of starting it is necessary to give the mill operator control of the fields of the generators which supply power to the mill motors, and a separate source of excitation for both generator and motor fields is required. This may be either an exciter direct connected to the motor generator set, or a separate exciter set.

A solenoid operated air circuit breaker must be placed in at least one side of each motor and generator line. In the other line should be either a lever switch or a duplicate breaker. The usual indicating instruments and field switches are placed on an instrument panel in the motor room.

Complete control of starting, stopping and adjusting the speed of the mill is concentrated on a desk board in the mill pulpit. On this desk are placed control switches for the line circuit breakers, and for the motor and generator field rheostats, together with the tachometers, motor ammeters, generator voltmeter, and generator ammeters.

If the generator is a compound wound machine, a contactor must be provided to short circuit its series field while the mill is being started, otherwise at very low voltage it will act as a series generator.

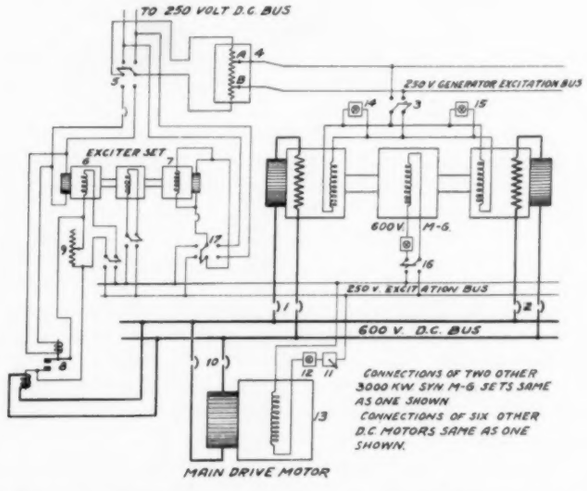

TO 250 VOLT D.C. BUS
230 V GENERATOR EXCITATION BUS
EXCITER SET
600V M-G.
250 V. EXCITATION BUS
600 V. D.C. BUS
CONNECTIONS OF TWO OTHER 3000 KW. SYN M-G. SETS SAME AS ONE SHOWN
CONNECTIONS OF SIX OTHER D.C. MOTORS SAME AS ONE SHOWN.
MAIN DRIVE MOTOR

FIG. 10—Elementary diagram of connections of dc-. motors and generators arranged for Ward Leonard starting, with regulator for voltage maintenance.

This contactor can be controlled by auxiliary switches on the generator field rheostat.

If more than one generator is connected to the same bus, special provisions must be made so that they will divide the load equally while being brought up to voltage. If the number of generators is small, this may be accomplished by connecting their shunt fields in series, controlling them with a common rheostat, and arranging to short circuit the series fields while starting.

Fig. 9 is an elementary diagram of connections of a drive involving two generators and several motors.

Referring to this diagram—15, 16 and 18 are solenoid operated air circuit breakers connecting the generators and motors to the bus. 17 is the equalizer switch between the two generators. Each generator has a series field 11, which is short circuited by the contactors 14 during the starting operation.

The shunt fields, 13, of the two generators are connected in series, and the high resistance hand operated rheostats, 8, shunting the fields, provide means for equalizing the voltages of the two machines.

In case of trouble with either generator, its armature may be cut out of circuit by simply opening its breakers and the equalizer switch. To provide means for disconnecting its field also, switches 6 and 7 and resistors 5 are included. Each resistor 5 is simply a permanent block of resistance having approximately the same ohms as the shunt field, so that when either switch 6 or 7 is closed in the upper position the total resistance in the field circuit is the same as when both fields are in series.

22 is the main generator field switch, and 10 is the main motor operated generator field rheostat which is of the reversing potentiometer type. It is in effect a resistance connected across the exciter bus, with two moving contacts. Suppose we call one contact "A" and the other "B." One end of the field is connected to "A" and the other to "B." In the neutral position the two contacts are together at the mid-point, and there is no voltage across the fields. Now if the operating motor revolves in one direction, contact "A" moves towards, say, the plus side of the resistor and "B" towards the minus, thus applying voltage to the fields in one direction. If the motor revolves in the opposite way, "A" will move towards minus and "B" towards plus, applying reversed excitation to the field. Thus this one rheostat gives complete control of the generator voltage from zero to the maximum value in either direction, and thereby permits of operating the motors in either the forward or reverse direction.

Rheostat 9 is hand operated, placed at the main switchboard to prevent the mill operator raising the generator voltage above a predetermined maximum value. In other words, it acts as a readily adjustable limit switch for the main rheostat. That is, with the potentiometer rheostat at the full field position, rheostat 9 should be adjusted to give normal generator voltage; then in starting the mill, the operator simply runs the main rheostat to maximum position, and does not have to watch the voltage. In fact, the forward control switch may be provided with a latch so the operator has only to close and latch it, when the mill will start and come up to speed. The "off" control switch should also be equipped with a latch.

Various interlocking connections are essential to prevent improper operation. Motor breakers 18 must be so interlocked that they cannot be closed unless motor field switch 19 is closed, and all generator breakers are open. This prevents starting the motor without field, and prevents connecting it to the bus unless the bus voltage is zero.

The control for generator breakers 15 and 16 must be arranged so they cannot be closed unless field switches 22, 6 and 7 are closed and rheostat 10 in the no field position. It must also be impossible to close breakers 15 unless switch 6 is in the down position, and impossible to close 16 unless 7 is in the down position.

To start the motors, the motor field switches are first closed. Then the operator in the pulpit closes motor breakers 18 by means of the control switches. Then he closes generator breakers 15 and 16. He then applies field to the generators by means of the rheostat control switch. The rate of acceleration is determined by the speed of the motor operated rheostat, which is always amply low. When the rheostat reaches the normal operating position, contactors 14 automatically open, and the mill is running ready for work.

To stop any motor, its breakers are opened. To stop all the motors, the generator breakers may be opened. A disadvantage of the scheme is that if the mill is running with one motor not in use, and it is desired to start that motor, the entire mill must be shut down, and all started at the same time.

When the drive involves a considerable number of generators, another scheme that may be used is to have the generators shunt wound or provided with a small amount of differential compound winding, so that they will have decidedly "drooping" characteristics, particularly at low voltage, and will, therefore, divide the load well. Then, in order to obtain good voltage regulation when the mill is running normally, a voltage regulator may be applied. This regulator may act either on the field of an exciter used to supply the generator fields alone, or on the field of a counter-e.m.f. generator in the field circuit.

The differential series fields make the operation of the generators so stable that it is not necessary to take the precaution of connecting all their shunt fields in series, but they may be connected in multiple, all, however, being fed through a common potentiometer type reversing rheostat. This makes it possible to cut a generator out or put one in service without shutting down the whole mill.

The elementary diagram in Fig. 10 shows such a scheme of connections, employing one exciter for the generators and another for the motors. The regulator in this case should be equipped with a stop so that the exciter voltage can never exceed 250, as it would otherwise tend to when the main generator voltage is reduced by means of the potentiometer rheostat.

As is evident from the foregoing description, individual magnetic control of each motor results in greater flexibility in application and operation of the drive, but on a continuous mill drive involving a number of d-c. motors supplied with power from suitable motor generators, the saving in cost due to the elimination of magnetic control will often justify the use of the Ward Leonard system. As usual, we cannot get something for nothing, and if we want the flexibility of magnetic control, we must be prepared to pay for it.

Conclusion

As was brought out in the first part of this article, the continuous mill with individually driven stands is responsible for the notable increase in the use of d-c. motors for main roll drives. If, when

you get ready to write the specifications for the electrical equipment for your next mill of this type, you find in the preceding pages some information or suggestions which will be of help to you, the purpose of this paper will have been fully accomplished.

DISCUSSION

W. W. Garrett*: Did I understand you to say that for an adjustable speed drive, d-c. motors with motor generators are sometimes less expensive than induction motors with Kraemer or Scherbius speed regulating equipments?

H. A. Winne†: That is correct; if the drive involves a number of motors which may be served by one or more common motor generators, the d-c. equipment may be less costly than a-c. On the other hand, if only one or two motors are involved the induction motor drive will usually be less expensive.

S. N. Roberts‡: Is it not true that a greater range of speed can be obtained with a d-c. motor than with induction motors and Scherbius or Kraemer regulating equipment?

H. A. Winne: That may or may not be the case, depending on several factors. On a Kraemer drive, if the d-c. machine used for regulation is direct connected to the induction motor, the obtainable range is limited by the characteristics of this d-c. machine, as it must deliver its maximum voltage at the minimum speed; a range of more than two to one can be economically obtained. If the d-c. machine is driven by a separate motor, a range down to practically zero speed can be had.

With the Scherbius system the range is limited to about 18 or 20 cycles either side of synchronism. On a 60 cycle system this will give a speed range corresponding to from 78 to 42 cycles, or almost 2:1. On a 25 cycle motor we could get from 43 down to 7 cycles if desired.

On a d-c. motor of the size applicable to main roll drives, it is not desirable to try to obtain by field control a range of more than 2.5 or at most 3 to 1, and 2 to 1 results in a better design. Of course by utilizing both armature voltage and field control, a much larger speed range can be secured.

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‡Elec. Supt., Atlantic Steel Co., Atlanta, Ga.

Direct Connected Hot Saws

By NELSON D. COOPER*

DIRECT connected hot saws, for steel mill and general industrial applications, have presented several unusual problems because of their proximity to metals worked at comparatively high temperatures.

Before it was possible to connect the saw directly to the driving motor, which would necessitate mounting and operating the motor in a position normally exposed to the intense heat radiated from the metal, it was first necessary to devise a practical method of protecting the motor from this heat, and to properly ventilate it. However, the advantages of a direct drive, as compared to the more common practice of employing a belt to transmit power from the motor to the saw, served as an impetus to steel mill engineers in solving the problems involved.

A very simple and ingenious method was developed for protecting the motor from the heat radiated by the metal being cut, and for properly ventilating it. These methods are extremely practical and have been applied to the hot saws of a rail mill. The result is a very compact and efficient saw, which is free from the troubles inherent in a belt drive, and for this reason the methods used should be of interest to steel mill engineers and operators.

The direct connected hot saws for this rail mill are shown in Fig. 1. This clearly illustrates the exposed position of the motor, and the manner in which it is shielded from the heat radiated by the hot metal which passes almost directly beneath it. Fig. 2 shows the general arrangement of one of these direct connected hot saws with its driving motor and flywheel, the baffle or shield for protecting the motor from the heat, and the method used for ventilation.

The motor used is of the squirrel cage type with high resistance end rings to secure sufficient slip to permit the energy stored in the flywheel to be utilized in making the cut. This motor is rated at 50 hp., 55°C. continuous, 220 volts, 3 phase, 25 cycles, 2 pole, 1400 rpm. and is built in an engine type frame for wall mounting. The motor is mounted on a tilting frame with its shaft arranged to rotate within two roller bearings with a special bearing construction. The saw is mounted directly on the motor shaft at one end and a solid flywheel on the other end.

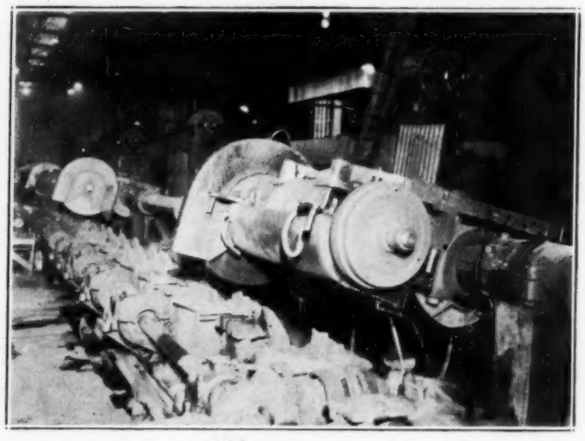

FIG. 1.

*Gen. Engr., Westinghouse Elec. & Mfg. Company.

The motor is entirely enclosed except for the openings around the frame for air outlets; this section of the frame is provided with a close mesh screen. The end brackets are of cast steel and specially constructed to provide for a sheet metal air conduit attachment arranged to pipe the cooling air to the motor from 7 to 8 feet away from the saw which is over the hot metal. Blowers of sufficient capacity to properly cool the motor are attached directly to its rotor. These blowers draw the cooling air into the motor through the air conduit attachments at each end, and force it out of the openings around the frame.

Also the motor has an especially wide air gap to permit of a slight wear in the bearings, or other mechanical defects which would tend to throw the rotor, etc. off center, without endangering the stator.

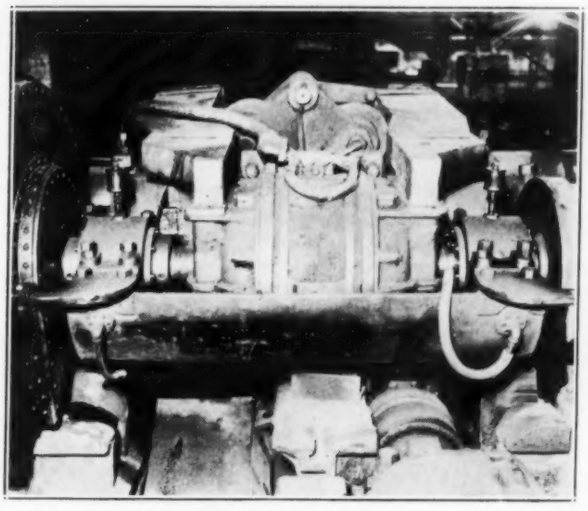

FIG. 2.

The motor and bearings are shielded from the extreme heat of the metal by a water cooled plate or tank which is placed between them and the hot metal. This plate or tank is curved to conform to the shape of the motor frame and consists of two pieces of sheet meal, welded together at the edges, but separated elsewhere to the extent of one inch. Water is fed into this tank space under pressure near the flywheel end and discharged against the saw. This scheme has proven quite satisfactory for keeping the motor cool.

The operator is fully protected from the saw by means of a heavily ribbed steel plate cover, securely fastened over the saw.

Another form of direct connected hot saw is the type of hot sawing and burring machine used for general industrial work in conjunction with upsetting and forging machines.

These saws are used for slitting jaw and T-head forgings preparatory to upsetting to the finished shape. Also forgings can be sawed from the bar at the same heat at which they are forged in the upsetter or hammer, and it is possible to smooth the finished forging by hot milling.

In this application it is unnecessary to shield the motor from the hot metal because the metal is of relatively small mass and, therefore, the heat radiated from it is not so intense at the motor.

The motors used for these saws are of about 10 or 15 horsepower capacity, depending upon the size of the saw, and run at or near 1800 rpm. Either alternating current or direct current totally enclosed motors are used. The alternating current motors used are of the squirrel cage type of standard construction; rated at 55°C. for ½ hour, and are capable of operating continuously at no load. The saws are equipped with ball bearings.

As the metal is fed into these saws by hand the load on the saw motor is likely to vary over a comparatively wide range, depending upon the operator, and therefore, it cannot be accurately calculated. However, the motors of the size and rating described generally prove satisfactory for these applications, and in installations where the motor tends to overheat, an air hose or other means of forced ventilation is all that is necessary to keep the motor cool.

In conclusion we may add that the success of the direct connected hot saws described in this article, which eliminate the use of a belt with its inherent ills, and the resulting compact and efficient units obtained, indicates that the future tendency will be to adopt this form of construction.

SPECIAL FEATURES OF TORONTO PLANT, FOLLANSBEE BROS. COMPANY, TORONTO, OHIO

(Continued from page 193)

the assembly of a number into one operation is worthy of note.

It was one of the first sheet mills to be completely electrical-driven throughout. It is a complete unit from the open hearth furnaces to the finished sheet, manufacturing its own electric power from coal obtained from its own mine adjacent to the plant.

The product of the mill bears the trade mark of "Follansbee Forge." It is not only a high grade open hearth sheet such as used in the automobile trade and allied industries, but the metal undergoes the unusual process of "hammering" before being rolled. The 11 x 11 open hearth ingot is "pressed" into a 6½ x 6½ bloom in a 1,000 ton steam hydraulic forging press before rolling into sheet bar.

A variety of fuels are used, this Company being one of the first to successfully adopt powdered coal to Sheet and Pair furnaces. Oil or producer gas is used in the four Open Hearth furnaces; powdered coal in the ingot heating furnaces and sheet and pair furnaces; washed producer gas in the tunnel annealing kilns, drying ovens, etc. Producer gas is furnished by a battery of eight Hughes automatic gas producers. The output from two of these producers is washed in a Flinn & Dreffein gas washing plant; one of the first bituminous coal washing plants of this country in the steel industry.

The Plant was designed principally for mass production and an unusual feature is the Annealing Equipment. This is carried out in two large Dressler tunnel annealing kilns; one 350 ft. in length and the other about 300 ft. Annealing is continuous, economical and under constant temperature control. They are fired with clean producer gas supplied by the gas washing plant.

The electrical features have been described in considerable detail by Mr. Murray and in general conform to accepted practice but some items required special consideration:

The large reversing motor drive on the bar mill is unusual for a mill of this size. At the time of the installation it was a question as to whether motor drive was economically justified on a reversing mill as small as this. The service calls for rolling a 6½ x 6½ bloom into ⅜ x 8″ sheet bar in 7 passes in a 30″ Bar mill. At Follansbee a similar mill of the same size is engine driven. The cost of a duplicate steam engine drive was considerably less than the reversing electrical equipment but after weighing the arguments for both sides motor drive was decided upon. The electrical equipment consists of a 2,000 HP. continuous rated 600 volt, D.C. reversing mill motor, with a speed range from 0-100 R.P.M., receiving mill current from a flywheel motor generator set, which in turn is driven by a 2200 V. 60 cycle, alternating current from the power house. Freedom from repairs and shutdowns, ease of control, low maintenance charges and other desirable features over a period of five years have justified this decision.

The two sheet mill trains are each driven from a 1500 HP. 240 R.P.M. 2300 volt induction motor through an enclosed herringbone gear and flexible coupling. The high speed shaft carries two flywheels, each of 25 tons. These sheet mills are operated on the "loose" rolling method and consequently both the roughing and finishing rolls are working continuously so that the motor load is continuous and greater than under "tight" rolling methods.

A drive of eight stands of 50″ cold rolls is driven by a 500 HP. induction motor. All auxiliary equipment, cranes, shears, etc., are electrically driven. Direct current is furnished by 3 motor generator sets.

Electric power is generated in a modern, high pressure, condensing steam turbine station located on the Ohio River, making available an adequate supply of condensing water. This power station was described in the July 25, 1922, issue of "Power."

The Toronto mill has an annual capacity of about 85,000 tons of high grade sheets suitable for the automobile trade, furniture manufacture and deep drawn requirements.

It is undesirable to deviate too strongly from certain accepted standards of design in the modern mill, but these standards have only been developed by a certain amount of pioneering over a period of years. Many new features were incorporated in the design of the Toronto Plant. They have proven meritorious and the power cost per ton of product is low; considerably lower than in the Follansbee Plant where a similar product is manufactured under a combination of steam and electrical operation with units of earlier types. Ease of control, low maintenance, and many desirable characteristics mark the modern electrically driven mill.

Items of Interest

The General Electric Co. announces the sale of the entire Sprague Electric Hoist and Winch business to the Shepard Electric Crane & Hoist Co. This includes the right to manufacture and sell, on and after April 1, 1927, all the hoist products formerly made by the General Electric Company.

The Shepard Electric Crane & Hoist Co., at its plant in Montour Falls, New York, will carry on the manufacture of Sprague Hoist products, which include: Sprague Worm Gear Electric Hoists and Trolleys in capacities from ¼ to 6 tons, with push button and rope control; Sprague Worm and Spur Gear Winches in capacities from 1 to 6 tons; and Repair Parts for all types of Sprague Hoists, Trolleys and Winches.

The Sprague Electric Hoist Division of the Shepard Electric Crane & Hoist Co., with headquarters at 30 Church Street, New York, N. Y., has been created to handle exclusively the sale of Sprague Hoists and Winches, entirely separate from the sale of Shepard Electric Cranes and Hoists. Mr. N. A. Hall, for many years associated with the Sprague Electric Works of the General Electric Co., has been appointed manager of this division.

The Reliance Electric and Engineering Co., Ivanhoe Road, Cleveland, Ohio, entertained the Cleveland District Section Friday, March 25, at their works in Cleveland. After an inspection trip throughout the works the Association and their guests were entertained at dinner in the Collingwood High School at Cleveland by the Reliance Company. In the evening Mr. A. M. MacCutcheon, Chief Designing Engineer of the Reliance Electric & Engrg. Co. presented a lecture relating his impressions and opinions of the Electrical practices in Europe. Mr. MacCutcheon had just returned from an extensive tour to all the leading industries in Europe.

The Roller-Smith Company, 233 Broadway, New York, announces two new Bulletins as follows:

Supplement No. 1 to Bulletin No. 550. This covers the new Type FR line of relays. These relays are used for many purposes but one of the principal applications is in connection with contact making instruments, meters and similar devices, wherein it is desired to have a small current operate devices requiring a relatively large current. The Type FR Relay is a new device not previously described in any trade paper.

Supplement No. 1 to Bulletin No. 100. This covers several types of instruments which are used principally in signal system and automatic train control work. The instruments themselves are not new ones but are standard devices modified to meet the requirements met with in testing of these classes.

STANDARDIZATION COMMITTEE MEETING

The Standardization Committee together with the Board of Directors of the A. I. & S. E. E. visited the Erie Works of the General Electric Co. and inspected the new Mill Type motors, which have been built under the standardized specifications of the Association of Iron and Steel Electrical Engineers. These motors are the first motors to be constructed under the Association's specifications.

The largest bearings ever built by the Timken Roller Bearing Company have just been completed and shipped, according to officials of the company. These bearings have a bore of 42 inches and an outside diameter of 61 9/16 inches. At thirty r.p.m. these bearings have a capacity of 2,750,000 pounds. The weight of each bearing is more than two tons.

Not only are these bearings the largest ever built in the Timken plant, but they will be installed by the Allis-Chalmers Manufacturing Company in the largest compeb mill in the world. This will be put in service in a plant manufacturing Portland cement. This mill has a diameter of 10 feet and 9 feet by 45 feet long and is used to take the Clinker from the cement kiln and grinding it to finished cement in one machine.

The advantages of the Timken Bearing in this machine will be the material reduction of the overall length of the machine, since the width of the Timken Bearings is only 13¼ inches. Likewise, Timken Bearings may be adequately enclosed, which will obviate the necessity of renewing the lubricant supply except at infrequent intervals. The tapered construction of the bearing permits the carrying of all loads, regardless of direction without the use of thrust plates or special thrust bearings.

The Harnischfeger Corporation announces the appointment of Mr. George W. Gimlich as manager of the Harnischfeger Sales Corporation Branch at Dallas, Texas.

Mr. Daniel J. Murphy, former manager at Dallas, will open a new office at Baltimore, Maryland.

The Appleton Electric Company, 1701 Wellington Avenue, Chicago, Ill., manufacturers of Unilets and other well known Appleton Electric products purchased on January first the complete foundry, equipment, buildings and land formerly owned by The Stowell Company of South Milwaukee, Wis., and are operating it as Plant No. 2 under the name of the Wisconsin Appleton Company.

In addition to the well known line of drawn steel Unilets as well as outlet boxes and covers the Appleton Electric Company makes a varied line of miscellaneous conduit fittings, many of which are made from malleable iron and the new line of Appleton No-Thread Unilets also made from malleable iron has made it imperative that this Company have a source of supply which will enable them to take care of all requirements and to make castings to their own specifications.

The Powerlet line of rigid conduit fittings, formerly manufactured by the Multi Electrical Manufacturing Company, has been purchased by the Chicago Fuse Manufacturing Company, of Chicago, Illinois.

Henceforth the Powerlet line will be manufactured and distributed by the Chicago Fuse Manufacturing Company, and will be known as Gem Powerlet Conduit Fittings.

Gem Powerlets are for use with rigid conduit—are made in various sizes and styles to meet all requirements of the trade. A new Gem Powerlet catalog will be ready for distribution very soon.

The Chicago Fuse Mfg. Company will continue their present products—Gem and Union Switch Boxes, Outlet Boxes, Fuses, Electrical Protective Materials and other wiring devices.

Arthur Keller, Chief Electrical Engineer of the Harnischfeger Corporation, died Saturday, March 12, at his home in Malwaukee, Wisconsin. He was born in Switzerland in 1882.

Mr. Keller had been connected with the Harnischfeger Corporation for the last twenty years and during that time had perfected much of the electrical equipment that goes into their cranes.

Mr. Keller was educated at the Universities of Zurich and Bien in Switzerland, and was employed by some of the largest electrical manufacturers in this country, as well as in Europe, before he joined the Harnischfeger Corporation.

He was a member of the American Institute of Electrical Engineers and of the Association of Iron and Steel Electrical Engineers.

The Trumbull-Vanderpoel Electric Manufacturing Co. has added to their line a new industrial switch known as the Current Breaker. This switch is safer, more positive acting and will have longer life than other types of switches. In design and action it is a distinct advance over present industrial safety switches because it will handle high voltages with minimum arcing and will stand the severest service. Contacting parts are enclosed in insulating pockets that limit and confine the actual amount of combustion to the minimum. It is made in 30, 60 and 100 amperes and 250 to 600 volts AC and DC. The features of its construction are that all parts are removable and can be replaced without disturbing the switch box or wiring and it is smaller than the average safety switch made.

The Electric Controller & Manufacturing Company of Cleveland announce the EC&M Type WB Brake, a new development to meet the demand for a shoe-brake giving longer life of brake shoe linings and permitting quick removal of the motor armature with brake wheel in place, without the necessity of taking the brake apart or disturbing any of its adjustments. It is an exceptionally fast operating brake.

The EC&M Type WB Brake is radically different from any other shoe-brake design in that no levers nor rods pass over the top of the brake wheel. The brake shoe arms are caused to operate in opposite directions by means of a simple lever movement having the connecting link within the base below the wheel. This improvement in shoe-brake design will be appreciated by operating departments where time required to change armatures causes costly delays and loss of production.

Steel castings, machined to a high degree of accuracy, and oversize bearing pins assure smooth operation. Brake shoe linings are of asbestos inter-

woven with wire and moulded to shape under heavy pressures. Linings are ½" thick on the smallest size brake and ¾" thick on the largest size, thus permitting a large amount of wear before replacement is needed.

Bulletin 1004 describes EC&M Type WB Brakes.

Mr. H. B. Newell has been elected Vice President and Director of the Fawcus Machine Company. Mr. Newell, for several years, has been Works Manager.

Mr. Murray is an active member of the A. I. & S. E. E. and has always taken a very active interest in all of the Association's activities.

His latest contribution to the Society's activities and to the Iron and Steel industry in general has been a very comprehensive editorial covering "Electrical Practices in a completely electrified Steel Sheet Plant."

J. S. MURRAY,

Electrical Engineer
Toronto Works Follansbee Bros. Co.
Toronto, Ohio

Mr. Murray received his early education and training in the Carnegie Institute of Technology, and he is also a graduate student of the electrical engineering course of the Westinghouse Electric and Manufacturing Company. In 1919 he was associated with the engineering staff of the Joseph Breslove, Consulting Engineers. In 1920 he was placed in charge of all construction work at the Follansbee Bros. Co., and later was appointed electrical engineer, the position which he now holds.

The R. D. Nuttall Co., Pittsburgh, Pa., have recently developed and placed on the market a complete line of speed reducers, which incorporate in their design Nuttall 7½ degree helical gears and Timken tapered roller bearings. This series of speed reducers is known as the SVR series and covers a range of from 1 to 150 horse power.

The SVR series are single reduction units, with reduction ratios ranging from 1 to 1 to 8 to 1; the high and low speed shafts being parallel and offset in the same plane.

The Nuttall Company has been building gear units for several years, using in their construction helical gears and Timken bearings, and the universal success of these units has lead the company to design and develop a complete line of speed reducers. Helical gears have numerous advantages over other types of gearing, they drive with the smoothness of a worm and worm wheel, yet have the high efficiency of a spur or herringbone gear; they have greater strength than spur gears and are equally strong as herringbones, besides having wearing qualities superior to either of the other types. One of the greatest advantages of helical gears is their ability to resist external thrust.

Timken tapered roller bearings insure absolute bearing dependability, combined with maximum efficiency. They hold the shafts in positive alignment and may be readily adjusted for wear.

Shafts in these reducers are carbon steel forgings, with the pinions integral. They are oil treated to give them additional strength. To correct any possible distortion caused by heat treatment the pinions are given a finish cut and the shafts are ground to close limits. In installations where loading requires shafts and pinions will made of allow steel. The reducer case is cast from the best grade grey iron, and is carefully assembled to reduce the possibility of oil leakage to a minimum.

A positive system of splash lubrication assures a good supply of lubricant to all the bearings and a protective oil film on the gear teeth at all times. The bottom of the case serves as a reservoir for the oil, which is picked up by the gear teeth and thrown by centrifugal force into oil troughs, through which it is lead to the bearings. Adequate return ducts are provided for the oil to drain back into the case and thus prevent leakage around the shafts. A settling basin is provided in the bottom of the case giving a chamber into which sediment in the oil can settle, thus increasing the efficiency of the lubricant.

The Crouse-Hinds Company, Syracuse, New York, is announcing a new line of Obround Condulets that incorporate many practical and time-saving features, based on a new method for fastening covers and wiring devices to a Condulet, known as the Wedge-Nut fastener. A few turns of the screw driver and the cover or wiring device is on, and on to stay, and cannot become loosened by vibration.

With this new form of construction there are no screws projecting inwardly to injure the conductors. Because of the unobstructed cover opening, conductors may be easily pulled without injury to them, for there are no projecting lugs. The unobstructed cover opening and large wiring chamber makes splicing and taping easy.

Another outstanding feature is that the covers and wiring devices may be conveniently installed even in difficult places as they can be turned so as to bring the fastening screws into an accessible position. Being complete units, no parts of cover or wiring devices can be lost during installation. The New Obround Condulets are made in many different types for all required uses.